

# **R**esearch and **T**echnology **O**bjectives and **P**lans **Summary**

*P-202*

**Fiscal Year 1993  
Research and  
Technology Program**

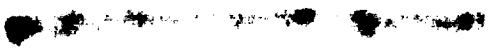
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# INTRODUCTION

This publication represents the NASA Research and Technology Program for FY 1993. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and summaries of the RTOPs listed in ascending accession number order. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

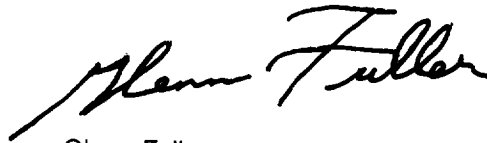
The RTOP Number Index provides a cross-index from the RTOP number assigned by the responsible NASA organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary*.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration  
Office of Aeronautics and Space Technology  
Washington, DC 20546-0001

Attn: Edna Templeton

Deputy Director, Resources and Management Systems Office (RB)

A handwritten signature in black ink, reading "Glenn Fuller". The signature is fluid and cursive, with the first name "Glenn" and last name "Fuller" clearly distinguishable.

Glenn Fuller  
Director, Resources and Management Systems Office  
Office of Aeronautics and Space Technology





# TABLE OF CONTENTS

## Office of Aeronautics and Space Technology

	PAGE
AERONAUTICS RESEARCH AND TECHNOLOGY BASE .....	1
Aerodynamics R&T .....	1
Propulsion and Power R&T .....	1
Materials and Structures R&T .....	2
Controls, Guidance and Human Factors R&T .....	3
Flight Systems R&T .....	3
Systems Analysis .....	4
Hypersonic R&T .....	4
Interdisciplinary Technology .....	5
AERONAUTICS SYSTEMS TECHNOLOGY PROGRAMS .....	6
High-Performance Computing .....	6
Materials & Structures Systems Technology .....	8
Rotorcraft Systems Technology .....	8
High-Performance Aircraft Systems Technology .....	9
Advanced Propulsion Systems Technology .....	9
Numerical Aerodynamic Simulation .....	10
High-Speed Research .....	10
Advanced Subsonic Technology .....	12
SPACE RESEARCH AND TECHNOLOGY BASE .....	13
Aerothermodynamics R&T .....	13
Space Energy Conversion R&T .....	13
Propulsion R&T .....	14
Materials and Structures R&T .....	15
Space Flight R&T .....	16
Systems Analysis .....	17
University Space Research .....	18
Information and Controls R&T .....	18
Human Support R&T .....	20
Space Communications R&T .....	20
Hypersonic R&T .....	22
In-Space Technology Experiments .....	22
Interdisciplinary Technology .....	23
CIVIL SPACE TECHNOLOGY INITIATIVE PROGRAM .....	24
Space Science Technology .....	24
Planetary Surface Technology .....	25
Transportation Technology .....	25
Space Platforms Technology .....	27
Operations Technology .....	27

<b>Office of Space Science and Applications</b>	<b>PAGE</b>
PLANETARY GEOLOGY/GEOPHYSICS .....	31
PLANETARY MATERIALS/GEOCHEMISTRY .....	31
PLANETARY ATMOSPHERES R&A .....	33
MARS DATA ANALYSIS .....	35
PLANETARY INSTRUMENT DEFINITION .....	36
SOLAR TERRESTRIAL SR&T .....	37
ADVANCED PROGRAMS .....	38
SOLAR TERRESTRIAL & ASTROPHYSICS SR&T .....	39
PLANETARY ASTRONOMY .....	45
LIFE SCIENCES SR&T .....	46
SOLAR TERRESTRIAL MISSION OPERATION AND DATA ANALYSIS .....	51
ASTROPHYSICS MISSION OPERATIONS AND DATA ANALYSIS .....	52
EOS DATA INFORMATION SYSTEM .....	53
EOS SCIENCE .....	55
SPACE PHYSICS THEORY .....	58
SPACE PHYSICS SR&T .....	58
SPACE PHYSICS ATD .....	59
SPACE PHYSICS SOUNDING ROCKET RESEARCH .....	59
SPACELAB PAYLOAD INSTRUMENT DEVELOPMENT/ASTROPHYSICS .....	59
ORIGINS OF SOLAR DYNAMICS .....	60
RADIATION AND DYNAMIC PROCESSES .....	61
HYDROLOGIC PROCESSES .....	63
ECOSYSTEM PROCESSES .....	67
BIOGEOCHEMICAL PROCESSES .....	70
ATMOSPHERIC PROCESSES .....	72
SOLID EARTH PROCESSES .....	75
CLIMATE AND HYDROLOGIC SYSTEMS MODELING AND DATA ANALYSIS .....	82
BIOGEOCHEMISTRY AND GEOPHYSICS MODELING AND DATA ANALYSIS .....	88
DATA SYSTEMS .....	93
MISSION OPERATIONS AND DATA ANALYSIS .....	97
SEARCH AND RESCUE MISSION .....	99
SPACE PROCESSING SCIENCE AND SPACELAB PAYLOAD DEVELOPMENT .....	99
SOUNDING ROCKETS .....	102
MISSION OPERATIONS AND DATA ANALYSIS .....	102

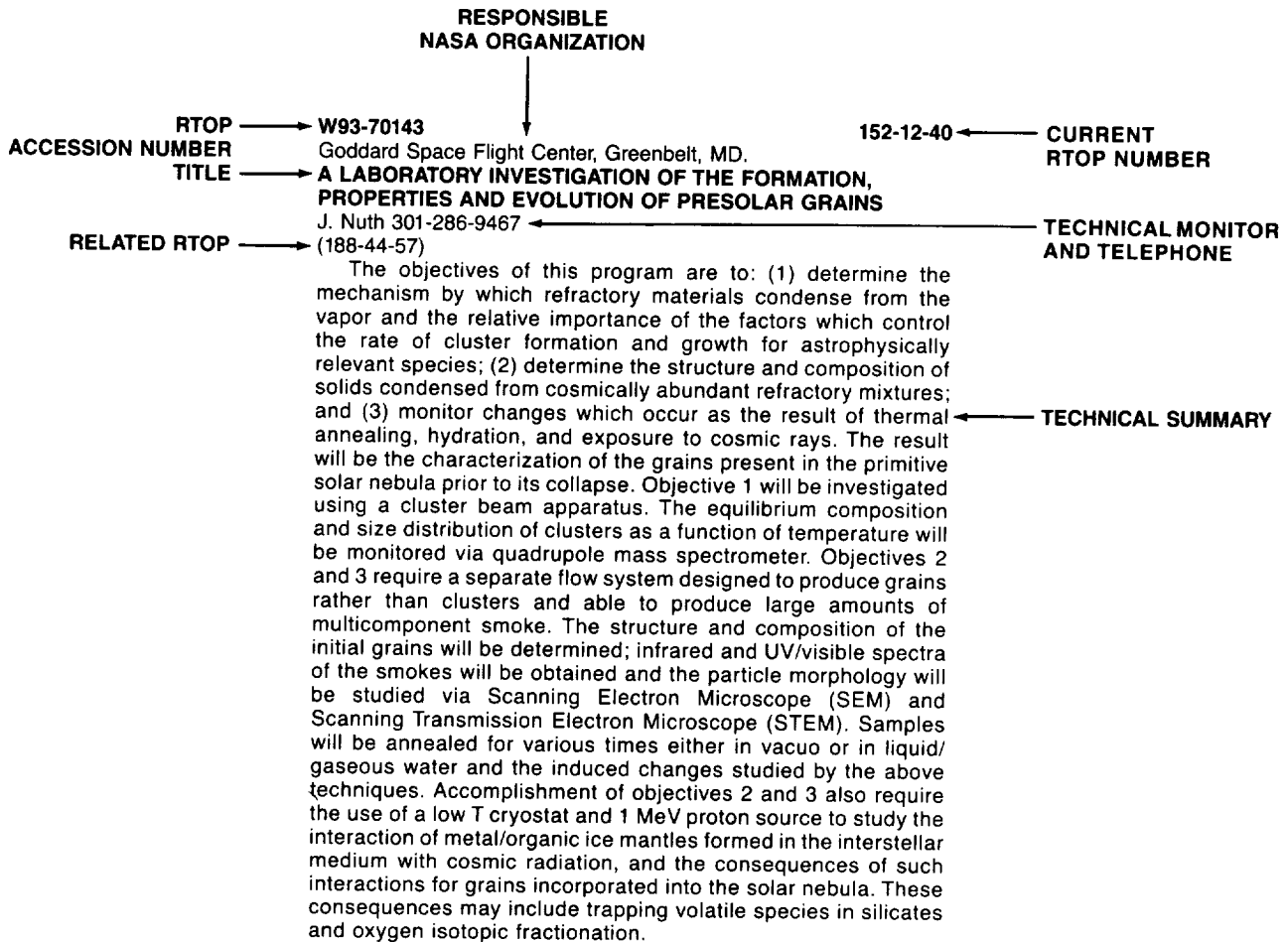
#### **Office of Space Communications**

ADVANCED SYSTEMS .....	103
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#### **Indexes**

SUBJECT INDEX .....	I-1
TECHNICAL MONITOR INDEX .....	I-73
RESPONSIBLE NASA ORGANIZATION INDEX .....	I-81
RTOP NUMBER INDEX .....	I-87

# TYPICAL CITATION AND TECHNICAL SUMMARY





# RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

*a summary*

FISCAL YEAR 1993

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

### Aeronautics Research and Technology Base

### Aerodynamics Research and Technology

W93-70001

(21) 505-59

Ames Research Center, Moffett Field, CA.

#### APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY

F. R. Bailey 415-604-5065

The objectives are: (1) to improve the understanding of the physics that influence vehicle aerodynamics and propulsion performance of components and complete configurations for the design of future aircraft, (2) to develop single and multidisciplinary analysis and design methodologies enabling the rapid design and development of future aircraft, and (3) to develop test techniques, measurement technologies, and facility concepts to support improved prediction techniques and improved analysis and design methodologies. The approach will be based on a synergistic combination of computer simulations and experimental testing. The necessary elements that comprise applications software for numerical modeling of fluid dynamic flows will be created, refined or modified. Wind tunnel experiments will be conducted to understand fluid physics, develop databases for turbulence modelling and validate computer programs.

W93-70002

(23) 505-59

Langley Research Center, Hampton, VA.

#### AERODYNAMICS RESEARCH AND TECHNOLOGY

Roy V. Harris, Jr. 804-864-6048

The objective is to develop an advanced and validated base of new aerodynamics technology for application to future generations of civil aircraft, and rotorcraft, and fighter aircraft. Ground-based, flight, and computational facilities are used to generate the advanced technology needed to accomplish the cited objectives. Wind tunnel tests and consultation to DoD, industry, and other agencies are provided consistent with available resources. This work is expected to result in advanced aerodynamic technologies for application by the aircraft industry in developing more efficient subsonic, supersonic, and hypersonic aircraft.

W93-70003

(55) 505-59

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### AERODYNAMICS RESEARCH AND TECHNOLOGY

L. M. Mack 818-354-2138

This part of the Transition/Turbulence Element of the Aerodynamics R&T program applies to the research area of laminar instability and transition. The overall objective is an understanding of the detailed physical processes that lead to boundary-layer transition, and the application of this knowledge to the prediction

and control of transition. The plan is to use numerical, analytical and experimental techniques to investigate the following four problems: (1) the mechanisms by which various external disturbance sources interact with the boundary layer to produce and modify instability waves and other disturbances (receptivity problem), the determination of the initial conditions of the instability waves, and the relative importance of competing influences on transition; (2) the propagation through the boundary layer of the instability wave trains and wave packets produced by either receptivity or by artificial means to the point where the final breakdown to turbulence starts; (3) the development of a method for the prediction of transition based on stability theory and knowledge of external disturbances; and (4) passive and active methods of transition control. As knowledge of transition is important for aircraft performance in all speed ranges and for all aerodynamic surfaces, the research will encompass two- and three-dimensional incompressible, subsonic, transonic, supersonic and hypersonic boundary layers.

ABSTRACTS

### Propulsion and Power Research and Technology

W93-70004

(22) 505-62

Lewis Research Center, Cleveland, OH.

#### PROPULSION AND POWER RESEARCH AND TECHNOLOGY

J. A. Ziemianski 216-433-3901

The broad objective is to carry out propulsion research and technology development at the discipline, component, and subsystem levels that will lead to significant improvements in capability and efficiency. Advances in the propulsion systems of a variety of aircraft operating over a broad range of flight regimes will be pursued through an integrated program of in-house, contract and grant activities. This work is to develop new technologies for government and industry propulsion system development. In the subsonic regime, research is aimed at reducing the fuel consumption of the large high-bypass-ratio turbofan engines powering the large transport aircraft and that of the small engines for rotorcraft and commuters by as much as 30 percent, reducing the fuel consumption of the rotary engine for general aviation by 40 percent, improving helicopter transmissions and reducing the noise of the turbofan engines by as much as 10 db. Research in supersonic propulsion focuses on advanced concepts for supersonic cruise which include vectoring nozzles, the supersonic throughflow fan, combined cycle turboramjets, variable geometry inlets and integrated flight/propulsion controls. Key tools will continue to be developed to enhance these research efforts: advanced computational methods for numerically modeling internal flows; nonintrusive measurement techniques; advanced

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

experimental capabilities; and aeropropulsion facilities. The facility efforts will continue to provide state-of-the art, highly productive experimental facilities in support of NASA, other government laboratories, industry and academia research programs.

### W93-70005

(23) 505-62

Langley Research Center, Hampton, VA.

#### PROPULSION AND POWER

Roy V. Harris, Jr. 804-864-6048

Advanced experimental and analytical techniques are used to develop a technology base for the effective integration of airbreathing propulsion systems into advanced high-performance fighter aircraft. Program focus is on providing basic information on the effects of the jet exhaust system on aircraft performance and maneuvering capability. New and innovative fighter aircraft concepts which required thrust vectoring or other novel control systems will be studied. An additional objective which is a very important element of this program is the study of the performance and vectoring capabilities of advanced nozzle concepts. Wind tunnel tests and consultation to DoD and industry are provided consistent with available resources. This work is expected to result in advanced aerodynamic technologies for application by the aircraft industry in developing more effective and efficient high-performance military aircraft.

## Materials and Structures Research and Technology

### W93-70006

(21) 505-63

Ames Research Center, Moffett Field, CA.

#### MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY

V. M. DeAngelis 805-258-3921

The objectives are to provide the materials and structures research and technology (R&T) necessary for significant improvements in the design, analysis, and structural performance of future generation aircraft; to develop techniques to enhance strain gage loads calibration/measurement methods; and to develop and demonstrate advanced structural excitation systems and new real-time algorithms for flight flutter clearance testing. The approach will be to: (1) conduct in-house and contract/grant studies to develop improved methods for strain gage location, calibration, and equation derivation for structural load measurement; (2) apply these techniques to existing aircraft structures for validation using experimental data obtained from both laboratory grounds tests and flight tests; (3) contract to small high technology businesses for the development of structural excitation systems, and evaluate the performance of these systems using currently available test bed aircraft; and (4) sponsor university grants for the development of real-time flutter analysis algorithms to be evaluated in the flight test environment.

### W93-70007

(10) 505-63

National Aeronautics and Space Administration, Washington, DC.

#### MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY

Kristin A. Hassenius 202-453-2810

The objective is to conduct fundamental research on advanced materials concepts for aeronautics. Advisory services to guide Research and Technology in advanced aerospace materials are provided by the National Materials Advisory Board, a unit of the National Academies of Science and Engineering. A Center for Computational Structures Technology (CST) was established at the NASA Langley Research Center and will be an integral part of the University of Virginia. The interdisciplinary program in airframe materials and structures includes research on advanced metallic

and composite airframe materials, properties of constituent fibers and matrix system for metal matrix and carbon/carbon materials, advanced structural analysis methods, fatigue response, environmental and thermal-structures response, and modeling and processing science for light-weight airframe structures. The interdisciplinary program in high temperature engine materials focuses on metal matrix composites and ceramic matrix composites. Emphasis will be placed on understanding the processing and properties of these materials. Key activities include the development of high temperature fibers; composite micromechanics at high temperature, including time-dependent behavior such as fatigue and creep; and the characterization and control of the fiber/matrix interface for both metal matrix composites and ceramic matrix composites.

### W93-70008

(22) 505-63

Lewis Research Center, Cleveland, OH.

#### MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY

C. E. Lowell 216-433-3191

There are two major objectives of this RTOP. The first is to advance the level of materials and processing technologies for high-temperature metallic, polymeric, and ceramic materials in order to contribute to improving the performance, life, reliability, structural efficiency, and/or to reducing the cost of future turbine engines. The emphasis of this work is directed toward developing a greater understanding of and modeling of the interrelationships among material composition/microstructure, fabrication processes, and mechanical/physical properties. The second major objective is to develop and verify advanced analysis and synthesis methods, advanced generic structural concepts, and advanced quantitative life prediction capabilities applicable to high temperature aerospace propulsion components. In addition, improved analytical methods to describe and predict the dynamic and aeroelastic response of aircraft turbine engine systems will be developed and experimentally validated. Emphasis will be on high temperature applications. Material behavior constitutive relations will be developed emphasizing anisotropy of metallic/ceramic/composite materials. Generic structural concepts will be conceived to exploit the capabilities of advanced material systems. This work is expected to result in advanced materials systems for future application by industry for high performance, more fuel efficient aeropropulsion systems.

### W93-70009

(23) 505-63

Langley Research Center, Hampton, VA.

#### MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY

C. P. Blankenship 804-864-6005

The objectives of this research are to provide structures and materials technologies that will enhance the performance, efficiency, and reliability of advanced commercial, military, and general aviation aircraft. The approach includes executing analytical and experimental programs in structures, materials, and acoustics with emphasis on: (1) aeroelasticity, unsteady aerodynamics, and aeroservoelasticity; (2) structural mechanics, thermal structures, and landing dynamics; (3) polymeric materials, metallic materials, and composite materials; (4) structural acoustics; (5) fatigue, fracture analysis, and life prediction; and (6) interdisciplinary analysis and optimization. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. The customers include the U.S. aircraft and rotorcraft industries, FAA, DOD, military aircraft industry, and the U.S. airline industry. Applications include aircraft structural design, aircraft materials and fabrication technologies, aeroelastic stability, and aircraft ground operations.

## Controls, Guidance, and Human Factors Research and Technology

W93-70010

(21) 505-64

Ames Research Center, Moffett Field, CA.

### CONTROLS, GUIDANCE, AND HUMAN FACTORS RESEARCH AND TECHNOLOGY

J. A. Albers 415-604-5070

The objective is to develop guidance, control, and crew/cockpit/air traffic control (ATC) interaction technologies to enable design of more effective civil and military aircraft and to ensure safe, efficient aircraft and air traffic control network operations. The approach will be to conduct analytic, field, and laboratory studies and evaluate concepts with in-flight simulation and flight demonstrations. Research will be conducted on control systems for superaugmented aircraft as well as control, guidance, and display systems to achieve more efficient ATC operations. Work will be done on the application of expert systems, computer vision, and guidance technology to enable automated rotorcraft flight in the nap-of-the-earth and maneuvering flight for fighter/attack aircraft. This is closely coupled with human factors research which focuses on providing requirements, guidelines, procedures, and technology concepts for piloting, air traffic control, and ground support operations in a human-centered design approach for efficient automation interfaces with human capabilities; developing tools for the design and evaluation of crew/cockpit interfaces and operational procedures to support more effective crew performance; and improving aviation system reliability and precision.

W93-70011

(23) 505-64

Langley Research Center, Hampton, VA.

### CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY

J. F. Creedon 804-864-6033

The objective of this RTOP is to provide the controls, guidance, and human factors research and technology (R&T) needed for continued improvements to all weather operational performance, efficiency, safety, reliability, and competitiveness of U.S. subsonic, supersonic, and high performance aircraft. Specific objectives include: development, validation, and demonstration of tools and methods for generating and evaluating reliable software and designing fault tolerant, electromagnetic environment (EME) resistant digital flight systems; application of advanced controls, displays, and decision making aids to increase cockpit efficiency and enhance airport terminal area productivity; multi-disciplinary efforts to develop and validate airborne wind shear detection/avoidance techniques; development and evaluation of advanced flight decks concepts for future aircraft; development of design methods for advanced high performance aircraft guidance and control (G&C) systems; providing advanced antenna analysis and design technology for all aircraft classes; development and validation of models and crew performance measures for detection of pilot/crew workload and awareness state; exploration of parallel computing system issues and evaluation of computer architectures; and investigation of computing technologies to achieve large performance increases. The approach taken includes establishing basic concepts and theories, developing and validating new concepts and innovative techniques through analysis, simulation, laboratory testing, and demonstration of the most promising concepts in flight tests. Computer science research is augmented through activities at the University of Illinois and LaRC sponsored ICASE. Flight crucial systems and software reliability and fault tolerance, flight management, flight deck design, controls, and human engineering technology developed under this RTOP directly supports and influences the design, development, and operation, by U.S. airframe manufacturers and airlines, of current and future subsonic and supersonic transport aircraft and enhances their safety, reliability, competitiveness, and productivity. In addition, this RTOP provides research products that contribute to the control, maneuverability, survivability, and operation of future high

performance military aircraft. Transfer of technology from this RTOP to industry/government users is accomplished through a combination of workshops, cooperative agreements, industry tours, publications and conferences, as well as direct contacts initiated by either LaRC or industry researchers.

W93-70012

(51) 505-64

Goddard Space Flight Center, Greenbelt, MD.

### CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY

B. L. Shaw 804-824-1654

The objective is to provide appropriate support to OAST research activities at the WFF Research Airport. This is focused around a variety of new and ongoing OAST programs. The support effort will be organized and implemented by project engineers and will include airport management, engineering, and maintenance; instrumentation and equipment purchases; fuel and other stock issues; and contractual services for aircraft fuel operations, control tower operations, line service support, crash-fire and rescue standby, and miscellaneous shop support.

## Flight Systems Research and Technology

W93-70013

(21) 505-68

Ames Research Center, Moffett Field, CA.

### FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY

D. H. Gatlin 805-258-3166

The overall objective is to provide the necessary research and technology development of advanced flight systems for application to future military and civil aircraft. This includes the necessary supportive development of testing techniques and instrumentation to enhance data accuracy. Research will be conducted as part of the NASA High-Angle-of-Attack Technology Program. Flight tests of the X-31 aircraft will also be conducted to validate integrated technologies and maneuver benefits. Flight experiments will be conducted using the High Alpha Research Vehicle (HARV). Unconventional approaches for high alpha flight control and maneuvering will be investigated. In support of the NASA Supersonic Short Take-off and Vertical Landing (STOVL) Program, a focused technology program will be conducted, including piloted simulation using the Vertical Motion Simulator and ground environment model tests. Non-intrusive optical air data laser systems will be evaluated through a joint NASA/DARPA program focusing on the capabilities of the technology as a measurement technique in the flight environment. A modern set of testbed aircraft will be established to support NASA developed flight systems research experiments. High speed experiments will be conducted on the SR-71 aircraft.

W93-70014

(22) 505-68

Lewis Research Center, Cleveland, OH.

### FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY

J. A. Ziemianski 216-433-3901

The overall objective of this effort is to provide for the necessary research and technology (R&T) development of advanced flight systems concepts for application to future military and civil aircraft. This part of the flight systems R&T program is focused on advancing critical technology needed to solve propulsion and icing problems associated with operation of military and civil aircraft and propulsion and control problems associated with operation of military high performance aircraft. The current plans for this research area are to develop analytical and experimental icing simulation techniques to study aircraft icing problems and to develop advanced ice protection system concepts to improve aircraft productivity, operational capability and safety, and to identify and develop propulsion technology for high performance aircraft. This work is expected to result in the design

of and analytical tools for future high performance aircraft. Improved analytical and experimental icing simulation techniques will help airframers reduce dependence on expensive and high risk flight testing in natural icing conditions. Advanced ice protection concepts provide airframers with alternatives to anti-icing by hot compressor bleed air, which will not be available from future high-bypass engines.

**W93-70015** (23) 505-68

Langley Research Center, Hampton, VA.

**FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY**

Roy V. Harris, Jr. 804-864-6048

The objectives of this RTOP are to develop advanced methods and vehicle concepts needed to significantly increase fighter maneuverability and agility considering the effects of high-angle-of-attack, vortex flows, unsteady aerodynamics, thrust vectoring, and advanced control laws and cockpit displays; and utilize flight experiments to validate key elements. This work will provide high-angle-of-attack technology in the areas of aerodynamics, advanced controls, and maneuver management for future applications by the industry and DOD in developing high-performance aircraft with greatly enhanced agility and combat effectiveness.

## Systems Analysis

**W93-70016** (21) 505-69

Ames Research Center, Moffett Field, CA.

**SYSTEMS ANALYSIS**

G. H. Kidwell 415-604-5886

There are two primary objectives to this RTOP. The first is to provide information for guiding the planning of advanced aircraft research, technology development, and flight research programs. Current efforts in this RTOP are directed toward advanced tiltrotor transports and toward defining broad aeronautics research requirements. The second objective is to develop advanced design and analysis methodology to improve both in-house and industry capabilities in design optimization and concurrent engineering. This multidisciplinary research is performed in support of Critical Disciplines objectives. The fundamental approach to these objectives is through analytical method development and application. Both in-house and contracted studies will be undertaken to perform the technical evaluation and sensitivity analysis of fully-integrated designs. Also, in-house studies addressing the application of advanced technology to baseline aircraft will be performed as potentially-high value concepts are identified. Most in-house computations are performed on engineering workstations. Other methods of acquiring supporting data, such as wind tunnel tests or piloted simulations, are used occasionally to support the design process.

**W93-70017** (10) 505-69

National Aeronautics and Space Administration, Washington, DC.

**SYSTEMS ANALYSIS**

Cecil C. Rosen, III 202-453-2789

This effort supports the overall planning and management of the Aeronautics Research and Technology program. Activities include a studies contract in support of OAST aeronautics technology program requirements, assessments, planning, and advocacy; membership in the Radio Technical Commission for Aeronautics (RTCA); and funding for the University Advanced Aeronautical Design Studies Program.

**W93-70018** (22) 505-69

Lewis Research Center, Cleveland, OH.

**SYSTEMS ANALYSIS**

D. C. Mikkelsen 216-977-7011

Studies will be conducted to establish the feasibility and potential benefits of advanced subsonic and supersonic propulsion concepts in order to identify technology research requirements and define opportunities for capitalizing on technology advances. Computer models will be developed and studies will be performed on a wide variety of engine cycles, propulsion systems, and engine/airframe combinations. Near term and long range aeropropulsion planning will be conducted to assist in the development of future NASA aeronautics programs. This work is expected to result in the identification of new/advanced airbreathing propulsion systems for the U.S. aeronautical industry that will lead to quieter, cleaner, more efficient civil aircraft, military aircraft having new/unique performance capabilities, and the ability to make such determinations in a shorter time and with greater modeling fidelity.

**W93-70019**

(23) 505-69

Langley Research Center, Hampton, VA.

**SYSTEMS ANALYSIS**

Roy V. Harris, Jr. 804-864-6048

The objective of this RTOP is to provide long-term guidance and direction to aeronautics research and technology programs performed by NASA and the nation's aviation industry. In-house and contract multidisciplinary systems studies identify high payoff, emerging technology needs, and opportunities that can lead to significant improvements or advancements in future civil or military aircraft, creation of new markets, and economic benefits. Studies assess the feasibility and potential benefits of highly integrated configurations incorporating improvements in aerodynamics, propulsion, propulsion-airframe integration, avionics and controls, and structures and materials. Tradeoff analyses are conducted to optimize parameters and to determine the sensitivity of the configuration concepts to the required technology development. This research is expected to result in integrating discipline technologies for evaluation and identification of high payoffs for focused subsonic and supersonic vehicle programs for future development by industry.

## Hypersonic Research and Technology

**W93-70020**

(21) 505-70

Ames Research Center, Moffett Field, CA.

**HYPERSONIC RESEARCH AND TECHNOLOGY**

K. L. Petersen 805-258-3189

The overall objectives are to advance fundamental understanding of basic physical and chemical processes and to develop predictive capabilities for analysis and design optimization of advanced airbreathing hypersonic vehicles. A synergistic interplay between computational, ground-based experimental, and flight research will be used to validate the technology. These efforts will provide the prerequisite research and technology (R&T) developments enabling an improved and validated technology base for application by industry in the development of future generation hypersonic flight vehicles. There are six efforts to be carried out. The first will be to develop the computational and experimental technologies required to accurately predict the aerodynamic and aerothermal characteristics of highly integrated, airbreathing hypersonic vehicles. The second will be to provide the experimental techniques and computational capabilities required to accurately simulate hypersonic propulsion flowfields and operating conditions. The third will be to provide the materials and structures R&T necessary for industry to make significant improvements in the performance, durability, and economy of future generation hypersonic aircraft operating at extreme temperatures. The fourth will be to develop the multidisciplinary modeling and analysis technology required to fully utilize advanced controls integration concepts on hypersonic vehicles and to conduct total vehicle



stability and dynamics response analyses. The fifth will be to establish, through conceptual design studies and systems analysis, the impacts of projected technological developments, alternate configuration approaches, and different mission requirements on the feasibility of advanced hypersonic vehicles. The sixth will be to provide a hypersonic experimental database of sufficient accuracy to calibrate/validate advanced Computational Fluid Dynamics (CFD) and engineering design codes used in the prediction of aerodynamic, propulsion, structural, thermal, and controls characteristics encountered on future hypersonic vehicles.

**W93-70021****505-70-00**

National Aeronautics and Space Administration, Washington, DC.

**HYPERSONIC TRAINING AND RESEARCH**

John S. Pyle 202-453-2744

The objective of this RTOP is to provide U.S. colleges and universities with increased focus and emphasis on the training and development of future researchers and technologists in the field of hypersonic aeronautics. In FY-1987, a jointly funded AF/Navy/NASA program was initiated to assist six academic institutions (selected by open competition) to develop graduate-level curriculum for training students in the study of flow physics associated with atmospheric flight at hypersonic speeds. In this initial program, curriculum development and basic research was primarily directed toward aerodynamic viscous flow phenomena in the Mach 5 to 15 flight regime. The program provided opportunities for conducting leading-edge research to train graduate students in preparation for careers in the government and U.S. industries. The initial grants with the six colleges and universities are to be completed in FY-1992. This highly successful program directly supported and graduated approximately 72 Master degrees, 57 Doctorate degrees (and indirectly supported numerous undergraduate students), and has been responsible for publishing over 256 technical reports and papers including over 26 major invited presentations for both national and international conferences in the five years of its existence. The intent of the current RTOP is to initiate a competition for the selection of new colleges and universities to participate in the program and to assure its continuation. The principal fields of study will be expanded to include hypersonic air-breathing propulsion, materials and structures, controls, and system integration research in addition to basic aero/aerothermodynamic flow physics.

**W93-70022****(22) 505-70**

Lewis Research Center, Cleveland, OH.

**HYPERSONIC RESEARCH AND TECHNOLOGY**

John E. Rohde 216-433-3949

The broad objective of the focused Hypersonic Research Program is to provide an enabling fundamental technology base and design methodology for airbreathing, hypersonic propulsion systems. Both hydrogen-fueled and hydrocarbon-fueled propulsion systems will be investigated to understand the physics of the high speed flow that exists in the components of these engines. Computational Fluid Dynamics (CFD) methods and models will be developed that will permit the design of these very complex and highly integrated engines, and non-intrusive diagnostic measuring systems will be developed and applied to verify the methods and designs. Advanced materials and advanced structures will be developed with the strength-to-weight and temperature capability that will enable the airbreathing engines and vehicles. Synthesis studies will be conducted on hypersonic vehicles to establish feasibility, assess potential benefits, and define critical technology needs. Focused research efforts will be pursued in five areas. The first area to be pursued will be propulsion flowpath and component development, analysis, and experimental testing. The research will verify the compatibility of an engine flowpath to function both as a scramjet at hypersonic speeds and as a thermally choked ramjet at lower speed conditions. The second effort will be to develop and verify improved CFD Methods and models to predict components and nose-to-tail integrated propulsion systems. The research will enhance the RPLUS code with higher-order upwind methods and 3-D grid overlay capabilities, and utilize

probability density function turbulence modeling in improved CFD codes. The third effort will be to develop and apply nonintrusive diagnostic instrumentation technology to understand the hypersonic flow in inlets and propulsion systems. The fourth effort will be to assess the potential benefits of and critical technology needs of both two-stage-to-orbit transatmospheric vehicles and Mach 5+ cruise vehicles. The research will refine the thermal management and structural weight analysis of the propulsion systems. The final effort will be to develop high temperature, high conductivity reinforced Gr/Cu composites with advanced fibers and/or processes for actively cooled engine panels with seals to enable variable geometry. The investigation will implement a new viscoplastic model in the MARC code for improved stress/strain life prediction of Gr/Cu composites. This work will provide fundamental propulsion technology base and design methodology that will enable the industry to develop complete classes of transatmospheric and hypersonic cruise vehicles. These vehicles will provide major benefits in terms of reduced cost of payload to orbit, life cycle cost, and operational flexibility and performance in terms of efficiency, range, and controlled hypersonic flight.

**W93-70023****(23) 505-70**

Langley Research Center, Hampton, VA.

**HYPERSONIC RESEARCH AND TECHNOLOGY**

L. M. Couch 804-864-3736

This research includes executing experimental and analytical programs to develop new, advanced technology in all areas of hypersonics: aerodynamics, propulsion, materials and structures, guidance and control, and systems analysis and multi-disciplinary integration. In addition, supporting the advances in these areas is research aimed toward the development of advanced test techniques, test support methods, and measurement technology. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. Results of this research will enable the development of efficient, viable hypersonic vehicles of all types, including reusable launch vehicles (both single and two stage) and cruise vehicles.

**Interdisciplinary Technology****W93-70024****(21) 505-90**

Ames Research Center, Moffett Field, CA.

**INTERDISCIPLINARY TECHNOLOGY**

C. Smith 415-604-5113

The objective of this RTOP is to promote and conduct innovative, leading-edge research in aeronautics through research and training grants, cooperative research efforts, and joint research institutes. The objectives are met through three elements within the RTOP: the Fund for Independent Research; the Graduate Program in Aeronautics; and the Joint University Institutes. The Fund for Independent Research supports innovative and high-risk basic research in aeronautics, usually by means of unsolicited proposals from universities. The Graduate Program in Aeronautics provides grants to support graduate training and research in aeronautics. A significant portion of this training will be through student research conducted at ARC. The Joint University Institute element provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics (JIAA) and the Research Institute for Advanced Computer Science (RIACS). The JIAA promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics. The RIACS pursues advances in computer science and computational methods required for long-range NASA goals.

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

**W93-70025** (10) 505-90  
National Aeronautics and Space Administration, Washington, DC.  
**INTERDISCIPLINARY TECHNOLOGY**  
Glenn C. Fuller 202-453-2790  
(506-90-00)

The objective of this effort is to provide for various support activities for the Aeronautics Research and Technology program. These activities include the Resident Research Associateship (RRA) Program; the administration of reviews, studies, and assessments of the ongoing and planned programs by the Aeronautics and Space Engineering Board (ASEB); and multidisciplinary training and research. The RRA program and the ASEB activities are contracted efforts, and the multidisciplinary training and research will be university grants.

**W93-70026** (22) 505-90  
Lewis Research Center, Cleveland, OH.  
**INTERDISCIPLINARY TECHNOLOGY**  
M. E. Goldstein 216-433-5825

The overall objective is to originate, support, promote, and maintain innovative, high-risk, long-term, university-type research through research and training grants, cooperative research efforts, and joint research institutes and activities. The program allows the Office of Aeronautics and Space Technology (OAST) to initiate fundamental studies in areas not presently included in a specific discipline program, to enhance LeRC's involvement with the academic community, and to sponsor graduate training in aeronautics. It is accomplished through five programs: (1) Fund for Independent Research; (2) Graduate Program in Aeronautics; (3) Institute for Computational Mechanics in Propulsion (ICOMP); (4) Lewis Research Academy; and (5) Ohio Aerospace Institute (OAI). The Fund for Independent Research support long-range, high-risk basic research activities at universities that are related to NASA's aeronautics activities. The Graduate Program in Aeronautics sponsors graduate training and research in areas that are relevant and acceptable to both NASA and the universities. These two programs involve grants which are selected by the members of the Lewis Research Advisory Board, who, at the request of the Chief Scientist, review unsolicited research proposals and proposals received in response to announcements of research opportunities. Those research proposals that are judged by the Chief Scientist to be worthy of support on a scientific or engineering basis are selected as candidates for funding. These proposals are then prioritized and funded to the extent permitted by available resources. The Lewis Research Academy consists of a group of internationally recognized basic researchers under the general cognizance of the Chief Scientist. Its primary purpose is to ensure that present and future Lewis programs achieve the maximum benefit from Lewis basic research activities. The objective of the Institute for Computational Mechanics in Propulsion is to develop accurate computer simulations for propulsion systems components as well as complete engine simulations. The objective of the Ohio Aerospace Institute is to expand Center involvement with the university community. The research supported under this RTOP is likely to lead to new technologies and concepts that will in turn lead to more fuel-efficient aircraft engines and new generations of aircraft engines that can operate at higher speeds and with improved performance.

**W93-70027** (23) 505-90  
Langley Research Center, Hampton, VA.  
**INTERDISCIPLINARY TECHNOLOGY**  
M. F. Card 804-864-6062

The objective of this work is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. This is accomplished through two program elements: (1) the Graduate Program in Aeronautics (GPA); and (2) the Joint University Institutes (JUI), which includes the Joint Institute for Advancement of Flight Sciences (JIAFS) and the Institute for Computer Applications in Science and Engineering (ICASE). The approach is as follows: GPA sponsors graduate research that is relevant to both NASA and the university

in the field of aeronautics and encourages a greater number of newly graduating U.S. citizen engineers to pursue graduate training. A significant portion of the student research is conducted at a NASA Center using NASA facilities. The JUI provides a core level of funding for the promotion of an active NASA/university interchange in order to maintain cooperative, innovative, venture research at the leading edge of the latest technology and techniques in science, engineering, mathematics, and computers. The application of this RTOP for NASA is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research and to increase the pool of American aerospace graduate students. The customers are as follows: (1) NASA, which receives innovative research results and training for its personnel in state-of-the-art academic methods and technology; (2) the aerospace industry, which hires highly-qualified graduate students who participate with university faculty in the research projects; and (3) university aerospace departments, which are able to use the funding to improve the quality of their research, students, and faculty.

## Aeronautics Systems Technology Programs

### High-Performance Computing

**W93-70028** (10) 509-10  
National Aeronautics and Space Administration, Washington, DC.  
**COMPUTATIONAL AEROSCIENCES**  
Lee B. Holcomb 202-453-2747

The objectives of the High Performance Computing and Communications (HPCC) program are to: (1) accelerate the development of computing hardware and software technologies capable of sustaining a teraFLOPS performance level on computational aerosciences applications; (2) provide researchers access to distributed HPCC software (e.g., project descriptions, distributors, source code); and (3) develop the next generations of computer and computational scientists. The approach will be to establish high performance computing testbeds and constitute application software teams to utilize and evaluate them; to set up systems software consortium to promote collaboration, exchange of ideas and sharing of software among HPCC software developers; and to provide funds for grants and fellowships to students and faculty members interested in computational aerosciences.

**W93-70029** (21) 509-10  
Ames Research Center, Moffett Field, CA.  
**COMPUTATIONAL AEROSCIENCES**  
K. G. Stevens, Jr. 415-604-5949

The objective is to support computational aerosciences by developing an understanding of the relationships and tradeoffs between algorithms, systems software, computer architectures and networks for computational aeroscience applications. Approaches, techniques and tools are needed to apply this understanding to the development of optimal hardware/software systems for this class of multidisciplinary aeroscience problems. The research will permit better utilization of emerging concurrent processors and will influence the design of computer systems crucial to NASA in the 1990s. It also will bring together computer science and computational physics expertise to analyze the requirements for multidisciplinary computational aerosciences, evaluate existing concepts and products and conduct the necessary research and development. The steps involved include: the development of requirements and evaluation of promising systems concepts using multidisciplinary algorithms; the development of techniques to validate system concepts; the building of application prototypes to

serve as proof of concept; and the establishment of scalable testbed systems. The computational aerospace activities and scalable testbed systems at ARC, LaRC and LeRC will be interconnected over T3 broadband Integrated Services Digital Network (ISDN) services which are the NASA part of the National Research and Education Network (NREN) program.

**W93-70030****(22) 509-10**

Lewis Research Center, Cleveland, OH.

**COMPUTATIONAL AEROSCIENCES**

Lester D. Nichols 216-433-3213

The objective of this work is to develop and demonstrate high performance computing techniques that will enable the aerospace industry to perform integrated, multidisciplinary simulation, analysis and optimization of propulsion system designs. Methodologies will be developed for numerically simulating the time-dependent physics of interacting propulsion components and entire systems. Resulting models, algorithms and codes will be implemented on scalable, massively parallel architecture computers. Advanced system software will be developed to provide aerospace industry users with an easy-to-use computational environment for propulsion simulation and analysis. Simulation testbeds will be established, and made available to industry, to support the development and testing of the required hardware and software.

**W93-70031****(23) 509-10**

Langley Research Center, Hampton, VA.

**COMPUTATIONAL/AEROSCIENCE**

Roy V. Harris, Jr. 804-864-6048

As part of the High-Performance Computing and Communications program, the goal of the Computational Aerosciences (CAS) Project at NASA LaRC is to develop necessary computational technology for the numerical simulation of complete aerospace vehicles for both design optimization and analysis throughout the flight envelope. The goal is supported by four specific objectives: to develop multidisciplinary computational models and methods for scalable, parallel computing systems; to accelerate the development of computing system hardware and software technologies capable of sustaining teraFLOPS performance level on computational aerospace applications; to demonstrate and evaluate computational methods and computer system technologies for selected aerospace vehicle and propulsion systems models on scalable, parallel computing systems; and to transfer computational methods and computer systems technologies to aerospace and computer industries. The general strategy of the project is to achieve understanding of all aspects of complete future implementations of CAS grand challenge applications on fully scaled teraFLOPS computing systems through a series of controlled limited-scope experiments utilizing grand challenge based subproblems and testcases. The CAS project at LaRC will focus on a high-speed civil transport (HSCT).

**W93-70032****(21) 509-20**

Ames Research Center, Moffett Field, CA.

**EARTH AND SPACE SCIENCES**

K. G. Stevens, Jr. 415-604-5949

The objective is to interconnect the NASA Science Centers to the National Research and Education Network (NREN). The approach will be the immediate development and implementation of an interim high performance network and the piloting of gigabit network technologies for implementation in the mid 1990s. These efforts will be carried out in collaboration with other agencies in the federal government. Specifically, NASA's NREN effort will support the interconnection of the NASA centers participating in the Federal High Performance Computational Communication Program (HPCCP) at speeds in the multimegabit range (45 Mbps and up) and develop additional connectivity (with new and other existing networks) to satisfy Earth and Space Sciences grand challenges. GSFC and JPL will be attached to the NSF T3 network for connectivity to remote investigators and to the Level 2 network (fast-packet, protocol independent) for inter-center connectivity. As a major NREN partner and user, the NREN project team will work with NSF, DOE and DARPA to enhance the national network

services such as resource management, routing control, security, user services and advanced operations. NREN will be supporting the High Performance Computing and Communication National Software Exchange which is managed by GSFC. Ames will develop DAVID 'books' to represent widely differing categories of data in support of GSFC.

**W93-70033****(10) 509-20**

National Aeronautics and Space Administration, Washington, DC.

**EARTH AND SPACE SCIENCES**

Lee B. Holcomb 202-453-2747

The objectives of the High Performance Computing and Communications (HPCC) program will be to: (1) accelerate the development of computing hardware and software technologies capable of sustaining a teraFLOPS performance level on Earth and space sciences applications; and (2) develop the next generations of computer and computational scientists. The approach will be to establish high performance computing testbeds and constitute application software teams to utilize and evaluate them; and to provide funds for grants and fellowships to students and faculty members interested in Earth and space sciences.

**W93-70034****(51) 509-20**

Goddard Space Flight Center, Greenbelt, MD.

**EARTH AND SPACE SCIENCES**

J. M. Hollis 301-286-7591

The goal of this RTOP is to accelerate the development and application of high performance computing technologies to meet the computational needs in numerical modeling and data analysis of the U.S. Earth and Space Science community. NASA-related Grand Challenges in science and data management serve as case studies for the test and evaluation of scalable parallel computing systems. The focus is on multidisciplinary applications involving a broad range of simulation and analysis. A NASA Research Announcement (NRA) was jointly issued by the Office of Aeronautics and Space Technology (OAST) and the Office of Space Science and Applications (OSSA) in FY-92 soliciting proposals from physical, computational, and computer scientists. NASA Grand Scientific Challenge applications may come from any NASA science discipline and are chosen for their potential direct impact to NASA, their national importance, and the technical challenge they give to the program. A peer review process will select 4 to 6 critical-mass Principal Investigator Teams to make progress toward solution of proposed Grand Challenge problems, and also will select 10 to 20 individual Guest Computational Investigators to develop related algorithms specifically for scalable parallel architectures. This RTOP will develop the High Performance Computing Software Exchange to provide an infrastructure that encourages Software Exchange to provide an infrastructure that encourages software reuse and the sharing of software modules across organizations through a uniformly interconnected set of software repositories. NASA has the responsibility for coordinating this activity for the Federal High Performance Computing and Communication (HPCC) Program. The objectives of this RTOP are as follows: (1) to develop algorithms and architecture testbeds capable of fully utilizing massively parallel concepts and scalable to sustained teraFLOPS performance; (2) to create a generalized software environment for massively parallel computing applications; and (3) to demonstrate the impact of these technologies on NASA research in Earth and space sciences physical phenomena. The objectives are approached as follows: (1) to use a NASA Research Announcement (NRA) to select Grand Challenge Applications and Principal Investigator Teams that require teraFLOPS computing for NASA science problems; (2) to provide successive generations of scalable computing systems as testbeds for the Grand Challenge applications, interconnect the investigators and the testbeds through high speed network links, provide a software development environment, and supporting computational techniques of the investigators; and (3) in collaboration with the investigator teams, conduct evaluations of the testbeds across applications and architectures leading to down select of the next generation of scalable teraFLOPS testbeds.

**W93-70035** (55) 509-20  
 Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**EARTH AND SPACE SCIENCES**  
 Robert Ferraro 818-354-1340

The objective of this effort is to establish and maintain a Multiple-Introduction Multiple-Data (MIMD) parallel processor testbed at JPL which will host MIMD applications developed for the NASA High Performance Computing and Communication (HPCC) program's, Earth and Space Science (ESS) Project. These applications include multidisciplinary modeling of Earth and space phenomena and analysis of data from remote sensing instruments. Included in the establishment of a MIMD environment is the development of systems software and user tools to support Grand Challenge computational investigators. The complete statement of technical approach, including milestones, is given in the HPCC Project Plan for Earth and Space Sciences, a joint project between JPL and the Goddard Space Flight Center. JPL's contribution to the project may be summarized as follows: The JPL ESS MIMD Testbed established in FY-92 will be maintained and expanded to serve as a development environment for NASA Grand Challenge science applications and software researchers, either by procuring a new system or by augmenting the existing one. Systems software and tools for parallel computers will be developed to assist science applications developers. This systems software includes tools for parallel data and functional decomposition, performance analysis, data visualization and solving partial differential equations such as parallel mesh generation and partitioners. Where appropriate and available, software also will be procured to aid in applications development. The testbed will serve as a beta test site for new systems software and parallel programming paradigms. Basic research projects, such as analysis of intra-application data movement and parallel I/O functionality, will be undertaken to understand important issues in scientific supercomputing on high performance architectures.

## Materials and Structures Systems Technology

**W93-70036** (22) 510-01  
 Lewis Research Center, Cleveland, OH.  
**ADVANCED HIGH TEMPERATURE ENGINE MATERIALS**  
 H. R. Gray 216-433-3230

The objectives of this work are to provide for the development of high temperature composite materials including the structural analysis methods required to do property, life, and failure mechanisms predictions and to provide the necessary technology to permit the transition of these innovative materials to applications in 21st century propulsion systems. Multidisciplinary development of technology for high temperature composites including ceramic, intermetallic, and polymeric will be conducted. Fiber/matrix combinations will be selected using thermodynamic and structural considerations for the development of composite structural materials for high temperature propulsion applications. A detailed understanding of composite architecture, processing, fiber/matrix interaction, life prediction and projected failure mechanisms will be developed for these advanced materials for use at temperatures up to 3000 F. Studies to synthesize matrix resins for use at 800 F with high toughness will be conducted. Revolutionary processing concepts will be explored for all classes of materials being developed under this program. Supporting technologies will be developed in high temperature sensors, nondestructive evaluation, and loads definition to insure an ability to take data at high temperatures on known quality materials under the correct stress and strain boundary conditions. Industry involvement and participation will be actively sought to insure both information transfer and the development of materials with the highest potential

for transfer to product usability. This work is focused on the development of technology for revolutionary advances in materials to enable the development of 21st century transport aircraft propulsion systems having greatly decreased specific fuel consumption, reduced direct operating costs, improved reliability, and extended life.

**W93-70037** (22) 510-02  
 Lewis Research Center, Cleveland, OH.  
**ADVANCED COMPOSITE MATERIALS TECHNOLOGY**  
 C. C. Chamis 216-433-3252

This RTOP effort is a part of the Advanced Composite Technology (ACT) program and has the specific objective to develop a formal framework (methods/computer codes) to quantify the reliability and risk in aircraft composite structures and thus minimize the effort and time required to certify and fly these types of structures. The formal framework will be developed by combining probabilistic structural analysis methods (available from the durability program for the Space Shuttle Main Engine, (SSME)) with probabilistic composite mechanics (micro and macro mechanics, laminate behavior, delaminations, fatigue and life, durability environmental effects, and structural fracture via progressive damage). The product will be a computer code for the Integrated Probabilistic Assessment of Composite Structures (IPACS). IPACS will simulate all aspects of composite structural behavior and structures as well as joints. IPACS will be jointly developed by Lewis personnel with the aid of support service contractors and with strong participation from aircraft industry and academia who also participate in the ACT program. IPACS will account for all possible failure modes in composite structures and will be verified by the industrial participants who will ultimately use it in the certification process of composite aircraft. The verification will include available data from certified and/or flight-qualified aircraft components and data generated during the course of the ACT program.

**W93-70038** (23) 510-02  
 Langley Research Center, Hampton, VA.  
**ADVANCED COMPOSITE MATERIALS TECHNOLOGY**  
 C. P. Blankenship 804-864-6005

The objective of this research is to conduct advanced concept development, analysis, fabrication, testing, and demonstration programs in composite structures and materials with emphasis on primary structures for aircraft applications. The benefits of advanced composites will be exploited to develop enabling technology and the required scientific basis for verified innovative lightweight, structurally efficient, damage-tolerant, and cost-effective materials and structural concepts. Innovative concepts will be developed and demonstrated for use in future primary aircraft structures. A multidisciplinary approach will be utilized involving advanced organic matrix materials, cost-effective fabrication techniques, innovative structural concepts, damage-tolerant designs, and fatigue/fracture characterization to promote new materials concepts that are integrated with structures technology. Structural mechanics technologies will be developed including analysis, design, and test methods for wing and fuselage components and subcomponents subjected to realistic loadings. This work is expected to provide advanced composite materials and structures technologies for use by the U.S. aircraft industry to maintain international competitiveness.

## Rotorcraft Systems Technology

**W93-70039** (21) 532-06  
 Ames Research Center, Moffett Field, CA.  
**ADVANCED ROTORCRAFT TECHNOLOGY**  
 W. Snyder 415-604-6570

The objective of this program is to advance rotorcraft systems technology for reduced noise and for advanced rotorcraft to enable advances in military and civil vehicles. A focused, integrated systems technology effort in acoustics and advanced configuration technology is necessary to regain U.S. preeminence in rotorcraft technology. Noise remains as one of the most persistent problems of conventional rotorcraft, limiting their effectiveness in civil and military applications. High subsonic speeds are needed to increase productivity and optimize effectiveness. Innovative low noise rotor technology will be developed by the acquisition of a modern airloads data base, refinement of predictive methods, and analytical and experimental investigations of innovative proprotor designs. Semi-empirical design methods will be improved and analytical and Computational Fluid Dynamics (CFD) codes will be validated. Scaling laws will be investigated by comparison of small and large scale model data with flight test data. Analytical capabilities, ground based facilities and flight research vehicles will be used to advance technology for advanced rotorcraft with special emphasis on tiltrotor configurations. Technology requirements for civil applications of the tiltrotor will be assessed. Operational, man/machine integration, and guidance and control issues including steep approaches and noise abatement profiles for civil tiltrotors will be investigated through simulation and flight test.

**W93-70040****(23) 532-06**

Langley Research Center, Hampton, VA.

**ADVANCED ROTORCRAFT TECHNOLOGY**

C. P. Blankenship 804-864-6005

There are two objectives for this research. The first objective is to develop the technology for improving rotor noise prediction methodology, noise design criteria, and noise reduction methodology for current and future high-speed rotorcraft. The second objective is to develop verified structural mechanics technology and design concepts needed to improve the performance of future high-speed rotorcraft primary structures. The approach for the first objective is to acquire acoustic data from tests of a variety of rotor and rotor system configurations and to utilize these data to develop and verify advanced noise prediction methods as well as innovative noise reduction concepts. The research is performed through contracts with major U.S. manufacturers and is coordinated with NASA in-house aeroacoustics research and with company independent research. The approach for the second objective is to develop advanced structural mechanics, design technology and concepts for primary structural applications and evaluate these for structural efficiency, damage tolerance, and improved performance. Tailored wing concepts will be developed and analyzed for advanced rotorcraft loading conditions. This research is performed through contracts with U.S. manufacturers and grants with U.S. universities. The customers for this research include the five major U.S. manufacturers of Rotorcraft for both military and commercial use. In addition, this research supports both DOD and FAA.

## High-Performance Aircraft Systems Technology

**W93-70041****(21) 533-02**

Ames Research Center, Moffett Field, CA.

**HIGH-PERFORMANCE FLIGHT RESEARCH**

C. R. Jarvis 805-258-3177

Generic high angle-of-attack research will be continued with an F-18 test aircraft. Under the joint NASA/USAF Advanced Fighter Technology Integration (AFTI) Program, the F-16 will continue Close Air Support (CAS) technology development. The F-15 Performance Seeking Control (PSC) Program will conduct single engine flight testing, to be followed by a design and development effort to

optimize the total integrated propulsion and flight control systems for two engine full envelope operation. Integrated flight/propulsion control techniques will be investigated to minimize the impact of aircraft flight control failures. The modified YAV-8B Harrier will be used to validate design methodologies for integrated flight and propulsion controls and develop design criteria for advanced STOVL aircraft. The X-29 Forward Swept Wing will be completed with publication of final reports. Final analysis and reporting of the results of the flight phase of the Supersonic Laminar Flow experiment on F-16 XL Ship 1 was initiated in FY-91. A separate Supersonic Laminar Flow Flight experiment will be initiated on F-16XL Ship 2 following flight evaluation of the baseline aircraft and engine.

**W93-70042****(22) 533-02**

Lewis Research Center, Cleveland, OH.

**HIGH PERFORMANCE FLIGHT RESEARCH**

J. A. Ziemianski 216-433-3901

Generic high angle-of-attack research will be conducted with an F-18 test aircraft. Of particular interest are the effects of high air flow angles due to aircraft maneuvers and the interaction with the aircraft forebody, the resulting flow field as ingested by the inlet system, and the response of the inlet to such flow fields. The objective is to use results of the aircraft experiments to correlate wind tunnel and Computational Fluid Dynamics (CFD) analyses. This work is expected to result in the design and analytical tools for advanced inlets for future highly maneuverable aircraft.

**W93-70043****(23) 533-02**

Langley Research Center, Hampton, VA.

**HIGH-PERFORMANCE FLIGHT RESEARCH**

Roy V. Harris, Jr. 804-864-6048

The objective of this RTOP is to provide support for the F-16XL High-Lift/Community Noise Flight Experiments Program. The approach will combine ground-based wind-tunnel, computational, and simulator studies with specific flight experiments to evaluate and validate concepts for the NASA High-Speed Research (HSR) Program. During Phase 1 of the HSR Program, the flight experiments will be limited to the baseline F-16XL configuration. The F-16XL Flight Project will provide technology directed at critical environmental concerns for the development of a high-speed civil transport (HSCT) aircraft that is economically competitive with long-haul subsonic aircraft.

## Advanced Propulsion Systems Technology

**W93-70044****(22) 535-03**

Lewis Research Center, Cleveland, OH.

**ADVANCED TURBOPROP SYSTEMS**

J. A. Ziemianski 216-433-3901

The objective of the Advanced Turboprop Systems effort is to develop ducted propeller technologies critical to the noise reduction of future Ultra High Bypass engines while achieving high efficiency and reliability. Noise prediction codes are developed and low noise cycles/concepts are experimentally evaluated in scale model wind tunnel tests which measure acoustic, aerodynamic, and structural performance. The technology developed is required by U.S. engine and airframe manufacturers in order to meet increased international/national noise rule stringency before the end of the decade.

**W93-70045****(23) 535-03**

Langley Research Center, Hampton, VA.

**ADVANCED TURBOPROP SYSTEMS**

C. P. Blankenship 804-864-6005

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

The objective of this research is to develop the aerodynamic and acoustics technologies necessary for the design of high performance turboprop/ducted fan/unducted fan powered aircraft. Configurations of interest are powered by highly loaded, multi-bladed, single-rotating, and counter-rotating propeller systems and large ducted fan systems. Aerodynamic research emphasis is on improved methodologies for achieving optimum airframe-propulsion integration. Acoustics research emphasizes methodologies to predict and control noise from the large ducted fan propulsion systems. The prediction methods are validated using wind tunnel data and results from a joint NASA/industry flight demonstration program. The improved prediction methods and criteria will be used to guide the design of advanced turboprop/unducted fan propellers, ducted fans, and aircraft configurations. The customers for this research include the U.S. aircraft engine manufacturers and the U.S. commercial transport aircraft companies. In addition, the FAA is a customer for this technology area in addressing community and airport noise issues.

### W93-70046

(22) 535-05

Lewis Research Center, Cleveland, OH.

### GA/COMMUTER ENGINE TECHNOLOGY

J. A. Ziemianski 216-433-3901

The objective of this effort is to provide the advanced technology base needed to insure the technical advantages of U.S. manufacturers in the future small engine marketplace. The approach is to evolve, evaluate, and verify critical advanced technology applicable to gas turbine engines of 250 to 5,000 shp suitable for general aviation, commuter, rotorcraft, and cruise missile applications. Analytical and experimental studies will emphasize revolutionary powerplant improvements in the 250 to 1,500+ shp range. This approach will provide industry with the capability to design and build small engines with performance, maintainability, and durability approaching that of large engines. The technology involved, while primarily applicable to small engines, is also applicable to higher thrust engines. This is especially true for very high pressure ratio engines (to 100 atm) which will approach the smaller engines in geometrical size. This research is aimed toward supplying the required analytical tools and engine sub-component technologies required for advanced rotorcraft (military and civilian), cruise missiles, general aviation, and commuter craft. In addition, the technologies are applicable to large engines, especially those incorporating high pressure ratios where size and boundary layer problems are accentuated.

## Numerical Aerodynamic Simulation

### W93-70047

(21) 536-01

Ames Research Center, Moffett Field, CA.

### NUMERICAL AERODYNAMIC SIMULATION (NAS)

D. Cooper 415-604-4500

NASA created the Numerical Aerodynamic Simulation (NAS) Program in 1985 to provide a full-service, state-of-the-art supercomputing facility for the national aeronautics and aerospace communities as well as to serve as a pathfinder for the development of future supercomputing systems. The NAS Program is at the forefront of an effort to develop supercomputing systems 1000 times faster than those of today and to integrate their use with ever-more-powerful mass storage systems, networks, and high performance workstations. The NAS vision is to use these powerful systems to provide by the year 2000 the nation's aerospace research and development community with the resources to simulate an entire aerospace vehicle in one-to-several hours. Efforts will include expanding the state-of-the-art of computational fluid dynamics to evolve to computational aeronautics applications. The NAS Program supports more than 1500 researchers and 350

projects across the nation--at the NASA Office of Aeronautics and Space Technology (OAST), other NASA centers and government agencies, in DoD, in industry, and in academia. Scientists have access to a complete supercomputing system that is upgraded regularly with a minimum impact on its use, together with a mass storage system; a nationwide system of high-speed networks; high performance graphics workstations; and an ever-increasing inventory of applications software. This RTOP covers the overall management of the Program, the facility, the development of the processing system and computational system research. It does not cover the operations elements which are covered in related RTOP 536-02.

### W93-70048

(21) 536-02

Ames Research Center, Moffett Field, CA.

### NAS OPERATIONS

D. Cooper 415-604-4500

NASA created the Numerical Aerodynamic Simulation (NAS) Program in 1985 to provide a full-service, state-of-the-art supercomputing facility for the national aeronautics and aerospace communities as well as to serve as a pathfinder for the development of future supercomputing systems. The NAS Program is at the forefront of an effort to develop supercomputing systems 1000 times faster than those of today and to integrate their use with ever-more-powerful mass storage systems, networks, and high performance workstations. The NAS vision is to use these powerful systems to provide by the year 2000 the nation's aerospace research and development community with the resources necessary to simulate an entire aerospace vehicle in one-to-several hours. Efforts will include expanding the state-of-the-art of computational fluid dynamics to evolve to computational aeronautics applications. The NAS Program supports more than 1500 researchers and 350 projects across the nation--at the NASA Office of Aeronautics and Space Technology (OAST), other NASA centers and government agencies, in DoD, in industry, and in academia. Scientists have access to a complete supercomputing system that is upgraded regularly with a minimum impact on its use, together with a mass storage system; a nationwide system of high-speed networks; high performance graphics workstations; and an ever-increasing inventory of applications software. This RTOP covers the operations elements of the NAS Program. It does not cover the overall management of the Program, the facility and development of the processing system which is covered in related RTOP 536-01.

## High-Speed Research

### W93-70049

(21) 537-01

Ames Research Center, Moffett Field, CA.

### ATMOSPHERIC EFFECTS

E. P. Condon 415-604-6071

The objective is to assess the atmospheric effects of a fleet of High-Speed Civil Transport (HSCT) aircraft and establish system studies to provide an independent evaluation, through conceptual design and tradeoff studies, of the technology developments that can provide a more environmentally acceptable and economically viable high-speed civil transport aircraft. Also, to provide brief investigations of technologies and/or concepts, such as those associated with 'what if?' type technical questions. Issues include potential depletion of stratospheric ozone, perturbations to atmospheric chemistry on a global scale, and the potential for long term climate change. The approach is to conduct a program of theoretical and experimental research including laboratory measurements and modeling of the chemical processes in the lower stratosphere; to develop new instrumentation for the measurement of stratospheric gases using existing platform aircraft; and, as required, to support the development of unique new high



altitude platform aircraft. An Ames-developed aircraft synthesis program, ACSYNT, including an economic analysis module, is being used to investigate the inter-disciplinary design issues associated with high-speed transport aircraft. The synthesis code will continue to be enhanced, as required, to enable the analysis of propulsion/airframe integration concerns, community noise, cruise altitude/emission effects, and sonic boom characteristics on economic viability. The economic analysis includes vehicle cost, total operating cost, and revenue requirements for a typical airline system. Tradeoff and sensitivity studies will indicate optimal parameter values, the benefits of technology improvements, and guide the formulation of research and technology plans. These results will be compared with contractor results and normalized to adjust for differing assumptions.

**W93-70050 (10) 537-01**

National Aeronautics and Space Administration, Washington, DC.

**ATMOSPHERIC EFFECTS**

Louis J. Williams 202-453-2828  
(537-02-00; 537-03-00)

The objective of this RTOP is to carry out critical analysis and review of past and ongoing research relevant to the Atmospheric Effects of Stratospheric Aircraft and Low Emissions Combustor Technology elements of NASA's High-Speed Research Program (HSRP). A task will be procured under an existing DoD contract with the Institute for Defense Analyses. Specific topics, to be assigned by the NASA Program Manager, shall be addressed by the Contractor to a depth consistent with the scope of resources.

**W93-70051 (22) 537-01**

Lewis Research Center, Cleveland, OH.

**ATMOSPHERIC EFFECTS**

L. H. Fishbach 216-977-7020

Studies will be conducted to identify the most promising engine and noise suppression concepts/technologies for a High-Speed Civil Transport (HSCT) and the economic penalties associated with satisfying projected environmental constraints. A spectrum of propulsion system concepts and technologies will be investigated in sufficient depth to identify preferred engine types and optimum cycle parameters to minimize the adverse effects of complying with expected airport noise and cruise emission constraints. Key technology needs will be identified as well as the associated benefits. After preliminary screening analyses by the engine companies and NASA, airframe manufacturers will perform a final assessment via a flyoff analysis to help downselect to two inlet/engine/nozzle systems. This work is expected to result in the identification of the HSCT engine and noise suppression concepts for the U.S. aeronautical industry that will satisfy projected environmental constraints with minimum economic impact.

**W93-70052 (23) 537-01**

Langley Research Center, Hampton, VA.

**ATMOSPHERIC EFFECTS**

Roy V. Harris, Jr. 804-864-6048

The objective of this RTOP is to provide guidance and direction to aeronautics/propulsion research and technical programs by NASA and the U.S. aviation industry to assure that any future fleet of High-Speed Civil Transports (HSCT's) would not have a detrimental effect on the Earth's atmosphere. The best available atmospheric models will be used and improved to assess the effect of a projected fleet of HSCT's on global ozone, stratospheric climatology, and the stratospheric-tropospheric radiative balance. An oversight panel of experts in the field will review the research which can ultimately provide guidance for an acceptable emissions budget and/or flight altitudes. Aircraft system studies will be conducted to determine the viability of technological solutions for environmental concerns and to identify high pay-off technology developments that will lead to an economically viable and environmentally acceptable HSCT. This research is expected to result in advanced technology for future application by industry in developing a High-Speed Civil Transport.

**W93-70053**

Ames Research Center, Moffett Field, CA.

**EMISSIONS AND SOURCE NOISE**

R. Kurkowski 415-604-6569

Three areas relating to the High Speed Civil Transport (HSCT) are addressed: low emission combustion, jet noise reduction, and nacelle airframe integration. The objectives for these three areas are the following: to develop NO(x) control technologies such that NO(x) production levels will be in the 3 to 8 g/kg (emission index) range; to develop high-speed jet noise reduction technology and concepts which would allow future HSCT's to comply with FAR Part 36-Stage 3 noise levels; and to investigate the acoustical, internal performance, and stability characteristics of candidate inlet systems, and propulsion airframe integration for HSCT aircraft. The approach for combustion analyses includes the development and use of advanced computation methods and codes to model the reacting turbulent flow in candidate combustor configurations. Emphasis will be given to the computational chemistry determination of the chemical kinetics. The approach to reduce high-speed jet noise will be to develop and verify advanced aerodynamic analyses and noise prediction capabilities through higher-fidelity computational models and controlled laboratory experiments using the 40 x 80 foot wind tunnel and advanced flow-field and noise measurements. Also, working with other centers and industry, the approach is to develop and conduct a CFD analysis and experimental program using the Ames Unitary Plan Wind Tunnel (UPWT) (9 x 7, 11 x 11) to study nacelle airframe integration, inlet stability, inlet acoustics, and nacelle effects on sonic boom.

**W93-70054 (22) 537-02**

Lewis Research Center, Cleveland, OH.

**EMISSIONS AND SOURCE NOISE**

E. J. Graber 216-433-5900

The overall objective of this effort is to explore advanced concepts in propulsion emissions and noise reduction, and develop engine component technology for future supersonic transports leading to no stratospheric ozone-layer damage and compliance with Federal Aviation Regulation 36 Stage 3 noise levels. The overall approach is to first develop and validate the required computational prediction codes using existing analysis tools wherever appropriate. Small scale laboratory and wind tunnel experiments will be conducted to improve the understanding of the key physics of both the noise and emissions problems and to provide code calibration/validation data. Wind tunnel tests of subscale nozzle configurations will then be conducted to demonstrate acceptable aerodynamic and acoustic performance across the take-off/transonic cruise performance range. Combustor subcomponent tests will be conducted and followed by rig tests of prototype combustor configurations to demonstrate acceptable NO(x) emissions levels and combustor efficiency. The work is focused on the development of a propulsion system technology base to provide industry with the information to make an informed 'go/no go' decision on a second generation supersonic transport.

**W93-70055 (23) 537-02**

Langley Research Center, Hampton, VA.

**EMISSIONS AND SOURCE NOISE**

C. P. Blankenship 804-864-6005

The objective of this research is to develop an advanced and validated base of supersonic jet noise reduction technology for application to future civil supersonic transports. The goal is technology to support an economically viable transport compliant with Federal Air Regulation 36 Stage 3. Improved understanding of the physical mechanisms by which supersonic flows generate noise is also sought along with the development of theories and validated data bases for accurate noise prediction and reduction. Analytical, computational, and experimental approaches are included in the research that is conducted in-house, by university grants, and with industry contracts. The experimental portion of the program emphasizes model scale laboratory studies under controlled conditions. The customers for this research include U.S. aircraft engine manufacturers and the U.S. commercial transport

aircraft industry. In addition, the FAA is a customer for this technology area in addressing community and airport noise issues.

**W93-70056**

(21) 537-03

Ames Research Center, Moffett Field, CA.  
**COMMUNITY NOISE AND SONIC BOOM**  
R. Kurkowski 415-604-6569

The objectives are to develop the design methodology for a High Speed Civil Transport (HSCT) in order to accomplish the following: (1) reduce community noise (i.e. takeoff and approach noise) to Federal Aviation Regulation (FAR) 36 Stage 3 levels; and (2) minimize the sonic boom impact. In a supporting area, the practical implementation of laminar flow control on highly swept wings at supersonic speeds offers the potential for significant reductions in cruise drag, thereby decreasing engine thrust requirements, engine size/weight, and associated fuel requirements, emissions, and noise. Community noise reduction involves the development of accurate system noise prediction methodologies for HSCT's, optimized engine placement for minimum noise impact, and efficient, low-speed, high-lift systems. Sonic boom research will concentrate on the development of low boom concepts and predictive methodology utilizing CFD and experimental techniques (unitary plan wind tunnel (UPWT), 9 x 7 self streamlining wind tunnel (SSWT)). Supersonic laminar flow control research will be conducted to provide the technology base, including design criteria and predictive technology for the practical implementation of laminar flow control techniques. This includes CFD analyses and predictions, ground experiments utilizing Ames Quiet Wind Tunnel, and flight experiments using the F-16XL Supersonic Laminar Flow Control (SLFC) research aircraft.

**W93-70057**

(23) 537-03

Langley Research Center, Hampton, VA.  
**COMMUNITY NOISE AND SONIC BOOM**  
Roy V. Harris, Jr. 804-864-6048

The objective of this RTOP is to provide understanding, innovative concepts, predictive capability, and minimization methodology for the acoustic disturbances and sonic boom generated by the operation of a High Speed Civil Transport (HSCT). An HSCT must be compliant with the intent of Federal Aviation Regulation (FAR) 36 Stage 3 noise rules to be allowed to take off and land at existing international airports. Meeting community noise rules will most likely impose the severest weight and efficiency penalties of the environmental concerns. Validated noise prediction and suppressor technology will be developed as well as improved high-lift systems to enable flight path optimization. Sonic boom prediction, propagation, minimization, and human perception must be better understood. A flight experiment and accompanying transition prediction and design methodology will develop and validate technology for practical, reliable, and maintainable supersonic laminar flow concepts. This research is expected to result in advanced technology for future application by industry in developing a High-Speed Civil Transport.

**W93-70058**

(22) 537-04

Lewis Research Center, Cleveland, OH.  
**ENABLING PROPULSION MATERIALS**  
J. R. Stephens 216-433-3195

The objective of this RTOP is, in cooperation with U.S. industry, to develop and demonstrate by 1999 the technical feasibility of high temperature, lightweight composites for critical components of gas turbine engines, so that a high speed civil transport (HSCT) may be introduced into service by the year 2005. To accomplish this objective, a major contractual effort, augmented by in-house research, will be undertaken over a seven-year period. Major emphasis will be on two engine components: the combustor and the exhaust nozzle. Research and development will focus on ceramic matrix composites for the combustor and intermetallic, metal, and ceramic matrix composites for the nozzle. Long-term durability at extremely high temperatures will require research on the following: fibers and fiber coatings; environmental durability; life prediction; failure analysis; composite fabrication; and joining

technology. Component design-material property trade-off studies will guide the research and development efforts. This work is intended to provide the necessary technology so that the U.S. jet engine manufacturers can make a favorable decision to proceed with development of engines for the HSCT.

## Advanced Subsonic Technology

**W93-70059**

(22) 538-01

Lewis Research Center, Cleveland, OH.  
**FLY-BY-LIGHT/POWER-BY-WIRE TECHNOLOGY**  
Gary T. Seng 216-433-3732

The overall objective of the program is to develop the technology base necessary for the confident application of integrated fly-by-light (FBL) and power-by-wire (PBW) systems to transport aircraft. Fly-by-light propulsion/flight control system technology will be advanced through research in electro-optic architectures and fiber optic sensors. The systems developed will be demonstrated through active (closed loop) ground and flight tests. Power-by-wire technology research will focus on the development of an integral starter/generator, an advanced power management and distribution system, and electromechanical actuators (EMA). The full system will be ground tested and the EMA's flight demonstrated as an integral part of the active control system.

**W93-70060**

(23) 538-01

Langley Research Center, Hampton, VA.  
**FLY-BY-LIGHT/POWER-BY-WIRE**  
J. F. Creedon 804-864-6033

The objective of this RTOP is to develop the technology base for confident application of integrated Fly-By-Light/Power-By-Wire (FBL/PBW) systems to transport aircraft. This is a joint LaRC and LeRC program. LeRC objectives are to develop and flight test the following: optical sensors and electro-optical converters; power management and distribution system; and electromechanical actuators. LaRC objectives are as follows: (1) to demonstrate architecture design and validation appropriate for certification of FBL/PBW systems; (2) to develop validated analytical and experimental assessment methodologies for electromagnetic interference (EMI) effects; and (3) to integrate/demonstrate end-to-end FBL/PBW systems in ground and flight tests. The approach of this RTOP will be to do the following: (1) devise, analyze, develop, fabricate, and test an optically based FBL/PBW architecture consisting of redundant optical sensors, fault-tolerant fiber-optic signaling, fault-tolerant computers, and a secondary power management and distribution system; (2) determine system level requirements, synthesize an architecture meeting the requirements, and validate that the architecture meets the requirements by applying design for validation concepts throughout the design process; (3) devise analytic and laboratory upset test schemes for EMI; and (4) assimilate and integrate technologies developed in other program elements, configure an evaluation system, and perform ground and flight tests. The full benefits of full authority digital control of transport aircraft have not yet been realized for U.S. aircraft. The intrinsic EMI immunity of optics technology can significantly enhance acceptance of full authority digital control by circumventing EMI concerns associated with Fly-By-Wire (FBW), and provide lifetime immunity to signal EMI. Additionally, FBL has the potential to greatly simplify certification against EMI by enabling bench tests of subsystems, as opposed to full airplane systems tests which are currently required to account for the interaction of EM threats such as High Intensity Radiated Fields (HIRF) with wire based signal transmission media.



**W93-70061****(23) 538-02**

Langley Research Center, Hampton, VA.

**AGING AIRCRAFT**

C. P. Blankenship 804-864-6005

The primary objective of the aging aircraft program is to provide the technology that will enhance the structural integrity of commercial aircraft. The specific research objectives are as follows: (1) to develop and verify advanced nondestructive evaluation (NDE) technology that can reliably and economically detect disbands, fatigue cracks, and corrosion of airframe structures; and (2) to develop and verify advanced mechanics-based prediction methodology which can be used to determine in-service inspection intervals, quantitatively evaluate inspection findings, and design and certify structural repairs. In addition, fuselage structural analysis methods will be developed and validated to assess overall structural integrity in the presence of fatigue damage. These research objectives will be accomplished through combined in-house, contract, and grant activity. To facilitate technology transfer, the program will be conducted in full cooperation with the U.S. airframe manufacturers and airline operators. The customers for this technology area include the U.S. transport aircraft manufacturers and commercial airline operators. In addition, the FAA and DOD are customers for these technologies in conducting their mission responsibilities.

flow-field computational techniques; providing real-gas chemistry models; utilizing wind tunnel, flight, and analytical prediction data to validate techniques for the design of future vehicles; providing the design and performance parameters on advanced vehicles to identify and analyze high payoff technologies; scoping convective and radiative heating problems on advanced concepts and developing prediction techniques; providing the experimental and analytical data base to improve understanding of real-gas chemistry, Mach number, and Reynolds number on current and advanced vehicles; and improving wind-tunnel technology, test techniques, and instrumentation for fundamental research. Analytical, computational, and experimental techniques are included in the fundamental research conducted in-house, by university grants, and under contract to industry. The experimental portion of the program emphasizes and utilizes the unique capabilities of the Langley Hypersonic Facilities Complex and the 8-Foot High Temperature Tunnel. The computational program requires extensive use of current super computers and parallel computers and utilization of future computer technology. Results will enhance the capabilities, reliability, versatility, and efficiency of future aerospace vehicles. The technology developed is used by NASA organizations, other government agencies, industry, and universities in the evaluation and design of improved or new aerospace vehicles.

## Space Research and Technology Base

### Aerothermodynamics Research and Technology

**W93-70062****(21) 506-40**

Ames Research Center, Moffett Field, CA.

**AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY**

J. O. Arnold 415-604-5265

The objective is to advance the fundamental understanding of aerodynamic flows in hypersonic flight regimes and to develop codes to permit performance optimization of future aerospace vehicles. Advanced computational methods and computer codes will be developed and validated for numerically simulating vehicle flow fields and then used to predict the thermal loads and the aerodynamic performance of the vehicle. The codes will yield solutions for the full Navier-Stokes equations for chemically reacting and radiating gases. Real gas properties, reaction rate constants, radiative transition probabilities, and high-temperature transport properties will be determined from computational chemistry methods. Such developments depend on results of both numerical simulations and experiments for improving and/or validating these complex codes. Experimental research of thermochemical nonequilibrium processes will be performed to provide a database and to develop an understanding of coupled rotation-vibration-dissociation phenomena and nonequilibrium radiation in high enthalpy, hyper-velocity flows. Research for future experimental ground based facilities to study real-gas hypersonic flows will be conducted. A candidate for study is an arc-driven hypersonic wind tunnel.

**W93-70063****(23) 506-40**

Langley Research Center, Hampton, VA.

**AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY**

W. R. Hook 804-864-6055

This research is to improve the fundamental understanding of aerodynamic and aerothermodynamic flow phenomena over ascent, entry, and aerobraking vehicles and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Emphasis is placed on providing

## Space Energy Conversion Research and Technology

**W93-70064****(22) 506-41**

Lewis Research Center, Cleveland, OH.

**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**

H. W. Brandhorst 216-433-6149

The objective of this work is to provide a research and technology development base leading to a spectrum of advanced space power systems and subsystems. Both generic and NASA specific missions guide systems level analyses which identify technological options with maximum system leverage/impact. The research generally aims at providing the technological base for emerging ten-to-hundred kilowatt and ultimately to megawatt level power system needs, while also recognizing and addressing agency and other needs up to the ten kilowatt level. Areas of study include photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, solar thermal and dynamic systems, advanced radiator concepts and surfaces, thermal control of advanced power electronics, and supporting technology for the SP-100 nuclear power system. Major thrusts are to improve performance, reliability and tolerance to the atomic oxygen, plasma and radiation environment while reducing cost and mass, where appropriate, for systems operating in the Low Earth Orbit (LEO), Geosynchronous Earth Orbit (GEO) and planetary environments. Advanced space power is a critical, enabling technology essential for the success of a wide range of NASA and other user applications. The above program provides key technologies for advanced LEO and GEO Space Platforms, Space Science Missions, lunar and Mars bases, planetary rovers, deep space platforms, and space transportation systems. Because all relevant technological approaches have their range of applicability and their limitations, it is essential that a broad range of robust options be pursued. Thus the work must span applications from subkilowatt to megawatts, static to dynamic with some being sun-independent. The multiple mission applicability of these technologies and the significant synergism that emerges during development thus leads to major Agency benefit.

**W93-70065 (10) 506-41**  
National Aeronautics and Space Administration, Washington, DC.  
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**  
Samuel L. Venneri 202-453-2760

The objective of this RTOP is to provide support to the headquarters operation of the OAST Space Energy Conversion Program. This will include operation of the multi-agency-supported power information center of the Interagency Advanced Power Group.

**W93-70066 (51) 506-41**  
Goddard Space Flight Center, Greenbelt, MD.  
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**  
T. D. Swanson 301-286-6952

The principal objective of this research is to develop, analyze, and test advanced thermal energy management concepts and components for future spacecraft and space facilities. The primary application is for the thermal control of instrumentation, sensors, and other heat dissipating equipment. Low to room temperature, long life applications will be stressed. Current focus is on such two-phase thermal control devices as cryogenic heat pipes and modular, space qualified heat pumps. These technologies have been identified as necessary to enhance and/or enable future missions. This work will be accomplished through: (1) research into basic thermo-fluid phenomena under micro and partial gravity; (2) development and test of various two-phase components and test verification; (3) development of analytical models and correlation to test data; and (4) small flight experiments. Thermal Energy Management involves the acquisition, transport, rejection, and (possibly) storage of heat. The thermal system is a basic utility which provides an essential service to other spacecraft systems such as power, communication, sensors, and propulsion. Effective accomplishment of the above objectives requires an organized approach involving systems level analysis, experimentation, and model development. The approach is to first evaluate proposed future missions to identify new technology needs, and then conceive, develop, and demonstrate appropriate solutions. Hardware development begins with laboratory breadboards, and successful concepts are carried to the brassboard level. Analytical models are developed in concert with the hardware, and correlated to test data (as available) for validation. At this point potential customers (such as flight projects) are brought into the effort as it transitions from generic research to application specific development. At this point the project will assume support for the effort.

**W93-70067 (55) 506-41**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY**  
C. P. Bankston 818-354-6793

The objective is to develop and demonstrate advanced technologies in the areas of power switching and control; chemical energy conversion; photovoltaic energy conversion; and thermal energy conversion for planetary spacecraft, rover, and probe power systems. The principal goal is to develop power technologies that minimize power system mass, volume and parts count, and enable small (mini) spacecraft systems. Also, we seek to meet the power requirements of future missions that may also include mini-rovers, penetrators, and operation in harsh (low and high temperature, high pressure) environments. The first goal is to advance power switching and control functions from discrete to monolithic technologies leading to increases in power density from 1W in(exp 3) to more than 10W in(exp 3), and 80 percent reduction in parts count, and the capability to integrate digital electronics and analog power functions in monolithic packages. The second goal is to develop and demonstrate high efficiency photovoltaic array technology that produces nearly 300 W/kg and 300 W sq m for earth orbital, planetary (to 5 A. U.), and electric propulsion missions. The third goal is to develop high cycle life, 100 W-hr/kg rechargeable batteries, including thin film rechargeable cells, and

develop thermal-to-electric conversion technologies capable of efficiencies of at least 10 percent (thermoelectrics) or 20 percent alkali metal thermoelectric converter (AMTEC) that would enable small, high performance, modular (mini), radioisotope power sources. The approach includes industry tasks for prototype demonstration. These goals are approached by: (1) developing solar cells for deep space applications by developing a method to prevent low intensity, low temperature degradation through electrical and radiation characterization of new, high performance cells; (2) developing ambient temperature lithium rechargeable cells capable of delivering at least 100 Whr/kg and 1000 cycles at 50 percent DOD, having an active shelf life of five years; (3) demonstrating efficiency and lifetime performance in AMTEC recirculating cells through thermal design optimization, current collection optimization and component lifetime improvements, to determine the feasibility of silicides as high performance thermoelectric materials; and (4) developing synchronous rectifier prototype hybrids to test and evaluate smart-pole hybrid prototypes, and test and evaluate opto-coupler hybrids.

## Propulsion Research and Technology

**W93-70068 (22) 506-42**  
Lewis Research Center, Cleveland, OH.  
**PROPULSION RESEARCH AND TECHNOLOGY**  
L. A. Diehl 216-977-7505

The objective is to provide propulsion technology, including cryogenic fluid management, for future Earth-to-Orbit vehicles, earth orbiting platforms and spacecraft, orbital transfer vehicles, space transfer vehicles, planetary spacecraft, and lunar/planetary/descent/ascent vehicles. Advanced propulsion will provide the capability to perform a variety of challenging space missions through major improvements in performance, reliability, operational flexibility and economy. Base R&T products are structured to have broad utility for a range of applications and customers. Customers include the mission centers and development centers of NASA, as well as the DOD and commercial launch services industry. Base R&T tasks are directed at critical issues across a broad spectrum of propulsion concepts as they apply to on-board, upperstage, transfer stage and Earth-to-Orbit propulsion systems and to cryogenic fluid management systems. The low thrust on-board propulsion arena includes both electric and chemical systems. Advances in diagnostics, modeling, materials and design methodologies are expected to result in a broad range of applications in the government and commercial earth orbiting platform, spacecraft and launch and transfer vehicle industries. The high thrust propulsion includes a range of propellant combinations and thrust sizes. Advances in understanding and modeling of critical combustion and turbomachinery processes, systems and health management systems is expected to result in application to future upperstage, transfer and launch systems. The cryogenic fluid management includes long term storage, pressurization, mass gaging and 1-g fluid transfer. Advances in these critical technologies are expected to result in application to cryogenic vehicles, in-space storage and lunar/planetary storage systems.

**W93-70069 (10) 506-42**  
National Aeronautics and Space Administration, Washington, DC.  
**PROPULSION RESEARCH AND TECHNOLOGY**  
Samuel L. Venneri 202-453-2760

The primary objective of this activity is to maintain continuous support of the Joint Army, Navy, NASA, Air Force (JANNAF) Interagency Propulsion Committee as an aid in planning and implementing the NASA program. Joint interagency tasks are undertaken when appropriate, such as publishing handbooks, manuals, or computer models, that will be beneficial to the

propulsion community as well as other potential users. For special interagency tasks, funding is transferred to the agency designated as responsible for the procurement action and contract monitoring. JANNAF general and topical conferences and workshops are of high importance to the conduct of NASA's propulsion related activities and in disseminating Research and Technology program results nationally.

**W93-70070****(55) 506-42**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**PROPULSION RESEARCH AND TECHNOLOGY**

P. W. Garrison 818-354-3575

To enable ambitious space exploration missions, research will be conducted to establish the feasibility of propulsion concepts which offer substantial performance increases relative to state-of-the-art propulsion systems. The major technical issues impeding the application of ion propulsion include demonstration of engine life, engine throttling, and reliability. The approach to resolving these issues will include extended-duration component testing, the development of a novel segmented thruster design and carbon/carbon grids, and the use of the negatively-biased three-grid technique for ion engine life testing. Magnetoplasmadynamic (MPD) thruster research will include the development, application, and experimental verification of electrode thermal models designed to address the critical issue of scaling thruster input powers into the megawatt range. Investigation into the design and testing of lithium MPD thrusters will also be pursued. Other technologies to be investigated include advanced forms of fission, fusion, and electric propulsion, including microwave electrothermal rockets, electrodeless electromagnetic plasma accelerators, and electrostatic molecular ion accelerators. Systems studies will be conducted to determine the theoretical mission benefits of new concepts and to define the feasibility issues and proof-of-concept research required to ready promising technologies for mission application. Concepts found to merit further consideration will be investigated through proof-of-concept research. Ion propulsion system technology and magnetoplasmadynamic (MPD) thruster technology for solar system exploration will be developed. Critical technology areas impeding the application of electric propulsion will be addressed through a combination of experimental and analytical research. Advanced propulsion concepts which can be developed into spacecraft propulsion systems capable of strongly enhancing the missions of interest to NASA in the first decades of the 21st century will be evaluated. Systems studies will be performed to assess the theoretical benefits of proposed advanced propulsion concepts in terms of quantifiable attributes such as required initial mass in Earth orbit or flight time. Basic feasibility issues associated with the proposed concepts will be identified. Feasibility issues associated with promising concepts will be resolved by performing theoretical or experimental studies both in-house and by contracts to universities, government laboratories, consultants, and private corporations.

## Materials and Structures Research and Technology

**W93-70071****(21) 506-43**

Ames Research Center, Moffett Field, CA.

**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

J. O. Arnold 415-604-5265

The objective is to provide advanced materials technology for future space systems with significant improvements in performance, durability, and economy. Emphasis is given to computational materials science and thermal protection materials.

In computational chemistry, the physical and chemical properties of molecules, small atomic clusters and gas-surface interactions are calculated from first principles. These computations, and extrapolations to larger systems, are being compared with experiments to obtain surface and bulk properties. Ames' unique arc jet facilities, ceramic and metallic materials laboratory, and analytical and computational capabilities are used to develop next generation materials and optimized thermal protection systems for advanced space transportation vehicles, enhanced Space Shuttle vehicles, aeroassisted space transfer vehicles (ASTV), planetary and solar probes, and the safe earth reentry of vehicles utilizing radioactive power sources. Candidate thermal protection system concepts and materials are subject to systematic development, analysis, and testing. Arc jet research conducted in this activity will assure that NASA materials characterization continues to be accomplished in state-of-the-art test facilities. Results from computational chemistry are used to study chemisorption, catalysis, corrosion, and the physical properties of polymers. Results from the material development, testing, and computational research activities are transferred to scientists and engineers working on Agency programs for entry technology (ASTV's, TAV's and probes), for the characterization of spacecraft materials for use in low-earth orbit, and the development of advanced ceramics, ceramic matrix composites (CMC's), and polymers for aero/space applications. These scientists and engineers represent our 'customers' and are employed by user field centers, other government agencies, aerospace industry, and academia. The objective is also to design, analyze, fabricate, and test a generic research cryogenic tank (GRCT), and to develop techniques and measurement systems, and the materials and structures technology needed by industry for significant improvements in the performance, durability, and economy of future generation cryogenic tankage for spacecraft.

**W93-70072****(10) 506-43**

National Aeronautics and Space Administration, Washington, DC.

**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

Samuel L. Venneri 202-453-2760

The objective of this RTOP is to develop a wide range of analytical tools and experimental techniques for use in the design, development, and analysis of the structures and structural dynamics of complex spacecraft and space structures. The program will be structured to foster innovative engineering solutions and design concepts for such vehicles. A number of key structural integrity issues will be addressed in order to develop the understanding and tools needed for the next generation of space structural design concepts.

**W93-70073****(22) 506-43**

Lewis Research Center, Cleveland, OH.

**MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

C. E. Lowell 216-433-3191

The objectives of this RTOP are to develop greater understanding of materials with aerospace propulsion and power potential and to develop guidelines for improving their physical/mechanical properties and reliability. Fundamental studies are aimed at investigating mechanical and other factors that limit material reliability, performance, and useful life. Fundamental studies are also aimed at identifying scientific concepts that might be applied to substantially improved aerospace materials. The research includes (1) material properties/performance enhancement via innovative application of nondestructive evaluation concepts/models for characterization of microstructure and mechanical properties; (2) understanding the basics of friction, wear, adhesion, thin film liquid lubrication, and the chemistry and morphology of solid lubricants; (3) exploration of new materials for heat storage and space power applications; and (4) fundamental chemistry of conductive polymer composites. The analytical and experimental results of this RTOP will have far reaching practical applications for a wide range of aerospace materials, structures, and components. The objective of the NASA Atomic Oxygen Effects Test Program effort is to quantify atomic oxygen erosion yield

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

dependencies of well characterized materials exposed to specific simulated low earth orbital environments. This work is expected to result in advanced materials systems for future application in advanced space power and propulsion systems.

**W93-70074**

(23) 506-43

Langley Research Center, Hampton, VA.

### **MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

C. P. Blankenship 804-864-6005

The objective of this research is to develop structures and materials technologies that will enhance the performance, efficiency, and reliability of spacecraft and space transportation systems. Spacecraft research emphasis is placed on (1) development of advanced polymeric, composite, and metallic materials that can be tailored to provide improved spacecraft performance; (2) development of concepts for automation of on-orbit construction of spacecraft; (3) development of analytical methods for prediction and control of spacecraft dynamics; and (4) development of interdisciplinary analysis and optimization methods for spacecraft design. Research in space transportation systems (STS) emphasizes (1) analytical and experimental verification of aerothermal structural loads; (2) thermal structures concepts and analysis methods; and (3) development of advanced metallic and composite materials for both cryogenic and high temperature applications. The approach uses analytical, computational, and experimental methods in fundamental research that is conducted in-house, by university grant, and under contract to industry. The customers for this research include U.S. spacecraft and space transportation manufacturers. In addition, the NASA development Centers are customers for this technology area in performance of their flight missions.

**W93-70075**

(55) 506-43

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

J. Moacanin 818-354-3178

The overall goal is to develop materials and structures technologies required for analysis, design, fabrication, characterization and control of long-life precision space structures and space optical systems, in order to enable or enhance future NASA missions in astrophysics, earth observing systems, and optical communications. Systems of interest include reflectors, antennas, optical benches, interferometers, advanced planetary cameras, and telescopes.

**W93-70076**

(62) 506-43

Marshall Space Flight Center, Huntsville, AL.

### **MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

J. B. Haussler 205-544-1762

The Long Duration Exposure Facility (LDEF) effort under this RTOP consists of two tasks. The first task is the continuation of the evaluation of LDEF experiments A0034, S0069, and A0171. These experiments all provided samples of materials that have been exposed to the environment of space for an extended period of time (5.8 years). Specialized analyses are required on the samples obtained. These analyses have direct applicability to Space Station, Advanced X-ray Astrophysics Facility (AXAF), Space Exploration Initiative (SEI) and materials usage in space in general. The second LDEF task in this RTOP supports the LDEF Ionizing Radiation Special Investigation Group (IRSIG). The principal objective of the IRSIG is to use LDEF data to rigorously test the accuracy of present models and methods for predicting ambient environment particle fluences and spectra, dose linear energy transfer spectra, secondary particles such as neutrons and recoils, and some radiation effects. The IRSIG program will also test a new model of trapped protons that includes directional effects. Extensive calculations using currently accepted and new models will be compared to the measurements. Full assessment of the accuracy of current and proposed calculation methods will be documented and disseminated. Methods and materials will be

archived. The objective of the Hydrogen Environment Embrittlement (HEE) resistant alloy development program is to improve the mechanical properties of NASA-23 and JBK-75 alloys in high pressure hydrogen by modifying their composition. Initial effort will focus on testing to verify an existing hypothesis in which the HEE resistance of an alloy is inversely related to the matrix electron/atom (e/a) ratio. Following this, the composition of NASA-23 will be modified to improve the HEE resistance while preserving its strength. The strength of JBK-75 will be improved in two steps: the first step will increase the volume fraction of gamma prime; the second step will increase the molybdenum and tungsten content of the alloy to enhance the strength of gamma matrix. These results will be achieved without sacrificing the good HEE resistance of JBK-75. Castability of the alloys will be demonstrated using standard casting shapes. A material property data base will be generated for both alloys. Advanced propulsion systems will benefit from the use of these alloys.

**W93-70077**

(72) 506-43

Lyndon B. Johnson Space Center, Houston, TX.

### **MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY**

S. L. Koontz 713-483-5906

(1) The objective of the oxygen effects on materials task is to develop a sound understanding of atomic oxygen and solar ultraviolet/visible ultraviolet (UV/VUV) effects on spacecraft materials so that ground based test methods can be evaluated and materials selection for NASA and DOD spacecraft can be made with confidence. The approach is to develop an accurate laboratory simulation of the low-earth orbit environment in the high velocity neutral atom beam at Los Alamos National Laboratories as well as a well characterized thermal atom test system at JSC. Materials reactivities produced in these two systems (some under accelerated test conditions) are compared with reactivities produced in several NASA flight experiments. Flight instruments supporting NASA and DOD missions in LEO are calibrated at the Los Alamos Facility. (2) The objective of the hypervelocity impact task is to develop an improved understanding of hypervelocity impact phenomena so that improved armor can be developed with confidence. Sophisticated high-speed camera systems record the details of hypervelocity impact events for comparison with hypervelocity impact hydrocodes. Validated hydrocodes are used to design improved armor. (3) The objective of the LDEF studies task is to obtain the maximum data yield possible from the LDEF samples held by JSC. Optical scanning of space exposed surfaces, classification of impact events and modeling of the orbital micrometeoroid and debris environment are done along with curation of LDEF materials.

## Space Flight Research and Technology

**W93-70078**

(22) 506-48

Lewis Research Center, Cleveland, OH.

### **SPACE FLIGHT RESEARCH AND TECHNOLOGY**

O. D. Gonzalez-Sanabria 216-433-5252

To define and develop NASA space technology experiments for the evaluation and validation of advanced space technologies being developed at the Lewis Research Center, LeRC is currently managing two flight projects on the power systems technology theme: Solar Array Module Plasma Interaction Experiment (SAMPIE) and Thermal Energy Storage (TES). SAMPIE will develop a space experiment to determine the environmental effects of the Low Earth Orbit (LEO) space plasma environment on the state-of-the-art solar modules biased to high potentials relative to the plasma. The experiment will fly as part of the OAST-2 mission, scheduled for the 2nd quarter of FY-94. This work will provide the data needed to validate the NASCAP/LEO modeling program

used for spacecraft power system analysis and design. TES will develop and fly an experiment to characterize void shape and location in phase change materials (PCM) used in a thermal energy storage canister configuration representative of solar dynamic power system design. Four experiments are planned with different combinations of PCM, geometries, and wettability. The first two experiments, TES-1 and TES-2, are scheduled to fly as part of the OAST-2 mission, scheduled for the 2nd quarter of FY-94. This experiment will provide data leading to higher thermal efficiency and increased reliability of performance for future heat receiver designs.

**W93-70079****(23) 506-48**

Langley Research Center, Hampton, VA.

**SPACE FLIGHT RESEARCH AND TECHNOLOGY**

F. Allario 804-864-6027

The objective of this research is the development of advanced space systems technologies through a broad-based program of in-flight experimental research. This program provides for data measurement and systems evaluation and verification in the true space flight environment, when such research cannot be adequately accomplished in ground-based simulations or facilities. The approach is (1) to develop and fly instruments which make use of the Space Shuttle Orbiter as a research vehicle to obtain data to be used to improve our ability to extrapolate ground-based data and predictions to the actual entry environment for advanced space transportation systems; and (2) to develop and fly instruments which use the Orbiter as an in-orbit test platform on which to conduct experiments to improve our understanding of the impact of the orbital environment on instrument performance for future science users.

**W93-70080****(51) 506-48**

Goddard Space Flight Center, Greenbelt, MD.

**SPACE FLIGHT RESEARCH AND TECHNOLOGY**

R. McIntosh 301-286-3478

There are three primary objectives for this RTOP. The first is to provide for the integration of the five experiments manifested for launch as part of the OAST-2 mission scheduled for February, 1994. These experiments include the Thermal Energy Storage Experiment (TES), Experimental Investigation of Spacecraft Glow (EISG), the Emulsion Chamber Technology Experiment (ECT), the Solar Array Module Plasma Interaction Experiment (SAMPPIE), and the Spacecraft Kinetic Infrared Test (SKIRT). The integration activities include thermal design, safety, mission operations, design, fabrication and qualification of unique hardware required for this set of instruments and development of analytical models. The Hitchhiker Project also advises and assists the experimenters in developing solutions for unique problems and in developing documentation and in interfacing with the NASA Space Shuttle System. The data obtained from these experiments benefit a broad range of future flight programs. The second part of this RTOP provides for the integration of the OAST Flyer mission manifested for mid 1995. This flight will make use of the SPARTAN carrier which will be deployed from the Shuttle bay for approximately forty hours as a free flyer. The integration activities include design and development of unique hardware, development of mechanical and thermal analytical models, development of safety and mission related documentation and development of mission scenarios. In addition, the SPARTAN Project will provide assistance to the experimenters in solving mission related interfacing and documentation problems. For this flight the SPARTAN will carry the Return Flux Experiment (REFLEX) and at least one other instrument. The third element of this RTOP involves the development of the REFLEX experiment. This experiment is designed to investigate the molecular contamination returned when material is outgassed from a spacecraft or instrument. The REFLEX will carry a magnetic sector mass spectrometer which has the capability to quantify the velocity, specie and density distribution of molecules passing through its entrance aperture. Two gases (neon and krypton) will be expelled from the REFLEX at known rates, and the mass spectrometer will measure how much of the gas returns to the experiment via scattering from collisions with

itself or the ambient environment. The experiment will also measure the effect of ambient atomic oxygen on materials deposited on quartz crystal microbalances prior to launch. The data obtained from this experiment will be used to validate our analytical models for contamination. Therefore, the data from this experiment will benefit many future flight programs.

**W93-70081****(72) 506-48**

Lyndon B. Johnson Space Center, Houston, TX.

**SPACE FLIGHT RESEARCH AND TECHNOLOGY**

R. L. Giesecke 713-283-5420

The objectives of the Orbiter Experiments (OEX) program are to collect data in the technology disciplines that will augment the research and technology base for future spacecraft design. Flight data relative to these disciplines will be collected by the development of unique experiments compatible with the flight operational capabilities of the Orbiter. The approach entails the following: (1) provide overall project and technical management, integration and support; and (2) conduct compatibility assessments for integration. During FY-93, it is anticipated that JSC will not be involved in new proposal evaluation activities in support of OAST. However, JSC will continue to provide support to OAST in the assessment of selected In-Step proposals as required.

## Systems Analysis

**W93-70082****(10) 506-49**

National Aeronautics and Space Administration, Washington, DC.

**SYSTEMS ANALYSIS**

Gregory Reck, M. 202-453-2733

The objective of this RTOP is to provide space program studies in support of OAST space technology program requirements, assessments, planning, and advocacy. The studies are intended to provide an analytical basis for planning activities in space research and technology. Areas of work will include: technology status and trends assessments; mission concepts and systems; long-range planning activities; and program technology needs, requirements, and opportunities. Activity will also include other study contracts, and services in support of advanced system concepts and policy analysis issues such as those relating to CSTI, exploration technology, and potential new or changing roles for OAST in space research and technology.

**W93-70083****(22) 506-49**

Lewis Research Center, Cleveland, OH.

**SYSTEM ANALYSIS**

O. D. Gonzalez-Sanabria 216-433-5252

The objective of this RTOP is to compare and evaluate various advanced propulsion system technologies that would best satisfy transportation requirements for a variety of future NASA missions. These advanced technologies would include high and low thrust systems utilizing chemical, solar and nuclear energy sources. These studies would include assessment and evaluation of the advanced propulsion technologies themselves as well as an evaluation of cryogenic technologies and requirements for these advanced propulsion systems. Studies would be performed primarily with an in-house core of existing civil service and support service contractors. Studies would evaluate advanced component technologies in complete propulsion system concepts. Mission design and analyses will be performed to assess the technologies from an overall mission perspective. Selected subtasks will be performed through an existing task order contract. System and mission analyses computer code capability used to evaluate technologies will be enhanced using in-house, university, and contractor expertise.

**W93-70084****(23) 506-49**

Langley Research Center, Hampton, VA.

**SYSTEMS ANALYSIS**

W. R. Hook 804-864-6055

The technical objectives of this research are to identify technology requirements for advanced space systems and to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technology development programs which satisfy these requirements; and to support the design and development of future spacecraft, advanced Earth- and space-based transportation vehicles, lunar and planetary transportation systems and space platforms and space stations via system-level analyses and supporting flight research. In-house and contracted analytical capabilities and computational facilities will be utilized to accomplish these objectives. Computer-aided engineering, design, and simulation capabilities will be expanded to meet the analysis and technology assessment needs. The results of this research will be utilized to focus technology and advanced development resources in the most effective areas to enhance future civil and military space missions. Conceptual design, systems analysis, and comparative assessment trade studies allow orderly and systematic identification of technology needs and benefits.

**W93-70085****(55) 506-49**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SYSTEMS ANALYSIS**

Frank Surber 818-354-2338

The objective is to identify and prioritize technology needs for future astrophysics, solar system exploration, earth sciences, life sciences and space physics missions; to identify and prioritize multi-mission technology needs in such areas as information systems, spacecraft subsystems, flight control and operations and ground test and processing; to evaluate the applicability of emerging technologies to NASA missions; and to provide development plans for high priority technologies. Selected advanced mission and instrument concept studies will be conducted jointly with Code S to ensure participation of both the user and the technology communities and the consideration of a broad range of technology options. Workshops will be held to facilitate the exchange of ideas and lay the foundations for technology development plans.

## University Space Research

**W93-70086****(10) 506-50**

National Aeronautics and Space Administration, Washington, DC.

**UNIVERSITY SPACE ENGINEERING RESEARCH**

Samuel L. Venneri 202-453-2760

The objective of the university space engineering research is to enhance and broaden the capabilities of the nation's engineering community to participate more effectively in the U.S. civil space program. The program responds to remedy the decline in the availability of qualified space engineers by making a long-term commitment to universities. The program is managed from the Office of Aeronautics and Space Technology at NASA Headquarters, utilizing technical monitors at NASA centers to foster collaborative arrangements, exchange of personnel, and the sharing of facilities between NASA and the universities. The program elements include the university space engineering research program, which supports interdisciplinary research centers; the university investigators research program, which provides grants to individuals with outstanding credentials; and the university advanced space design program, which funds advanced systems study courses at the senior level.

## Information and Controls Research and Technology

**W93-70087****(10) 506-59**

National Aeronautics and Space Administration, Washington, DC.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

David B. Lavery 202-453-2861

The objective of this activity is to conduct fundamental research in telerobotic space operations, including the development of a wide range of analytic tools and experimental techniques for use in space operations research with particular emphasis on telerobotics development. This will be augmented by further study of zero-G anthropometrics, automation, robotics, and artificial intelligence applications. The task will be conducted at the University of Maryland.

**W93-70088****(21) 506-59**

Ames Research Center, Moffett Field, CA.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

H. Lum 415-604-6544

The objective is to achieve innovative advances in information acquisition, understanding, and processing by integrating the research efforts in sensors, artificial intelligence (AI), robotics, advanced data architectures, photonics, and human factors engineering. Research is focused towards increased science and engineering productivity through the use of advanced information systems concepts with lower costs, and no compromise to mission safety. The approach in sensors research is to utilize and characterize, through extensive in-house, low-background testing, recent developments in materials such as improved semiconductors and recent advancements in layered devices such as impurity band conduction detectors to achieve advanced detectors for astronomy. The approach in AI research is to integrate fundamental concepts in machine learning, pattern recognition and classification, and large scale knowledge base technology into software tools for scientific data base analysis and model building, automatic of diagnosis and scheduling systems, and software analysis and reusability leveraging DARPA technology where feasible. The approach in robotics research is to evaluate integrated knowledge-based systems for mobile intelligent space robotics systems through demonstrations at Stanford University's Aerospace Robotics Laboratory. The approach in advanced data systems research is to evaluate adaptive neural networks capable of recognizing sensor patterns indicative of impending engine and structural failures using information from distributed sensor arrays, and to integrate concepts into an adaptive reconfigurable controller. The approach in photonics research is to develop a world-class in-house team/environment in collaboration with industry, academia, and other Government agencies, e.g., DARPA, and to conduct extensive in-house demonstrations of new optical technologies to achieve at least an order of magnitude improvement over equivalent digital processors in real-time image processing using advanced materials and devices such as fiber optic sensors, novel neuromorphic elements, and materials derived from biological sources. The approach in human factors research is to collaborate with operations centers in defining operational requirements and testing prototype systems leveraging extensive experience in aeronautical human factors to identify opportunities for high-impact research.

**W93-70089****(23) 506-59**

Langley Research Center, Hampton, VA.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

J. F. Creedon 804-864-6033

This RTOP provides for the following: fundamental and applied guidance, navigation, and control (GN&C) Research & Technology for advanced spacecraft, space transportation systems, and large flexible space structures/platforms; development and validation of



technology for advanced data and information processing systems and networks for space applications; development and laboratory testing of microwave remote sensor technology for geostationary and low Earth orbit applications; development of electromagnetic (EM) analysis methods for predicting the performance of large aperture systems; development and evaluation of advanced technology for space telerobotics applications; and investigation and laboratory implementation of advanced sensors and actuators for control of large space systems. The approach taken includes establishing basic concepts and theories; developing and validating new concepts and innovative techniques through analysis, simulation, and laboratory testing; and demonstration and transfer of technology of the most promising concepts through flight tests or technology bridging activities with a NASA development center or industry partner. Advanced GN&C, information and data processing, large space systems control, radiometer systems, telerobotics, and control sensors and actuators technology developed and evaluated under this RTOP provides new, innovative concepts for use in future NASA and industry space programs such as the National Launch System (NLS), Space Station Freedom (SSF), Mars and Lunar exploration/exploitation, Earth Observing System (EOS), and Space Transportation System (STS). Novel concepts and validated technology from this RTOP are transferred to NASA development center and industry users through workshops, technology bridging activities, cooperative agreements, publications and presentations, industry tours, as well as direct discussions initiated by either LaRC or the space technology user community. Primary customers are NASA development centers and program managers for Code R focussed programs and DOD/civilian space programs.

**W93-70090****(51) 506-59**

Goddard Space Flight Center, Greenbelt, MD.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

H. Plotkin 301-286-6185

The objectives of this RTOP are the following: to reduce burgeoning operational costs through knowledge-based automated software reuse, and develop an automated software management environment to monitor and improve software development efficiency and reliability; to develop systems to handle very large multi-source data bases managed at distributed locations; to apply expert systems to aid in extracting correlative information in complex data bases; to develop an Intelligent Information Fusion System; to encode multi-spectral image data; to develop methodologies for uniformly accessing heterogeneous software repositories; to perform research on novel improved spaceborne detectors for cosmic-ray, x-ray, and infrared radiation; to develop cosmic ray spectrometers based on solid-state silicon strip detectors; to develop high spectral resolution x-ray detectors for astrophysics using low temperature superconducting absorbers and either tunnel junctions or microcalorimeters; and to develop thermal IR detectors, operating at 65K, for outer-planet missions, employing composite-type infrared bolometers with high temperature superconducting thin films as the thermometer.

**W93-70091****(55) 506-59**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

Richard Key 818-354-3060

This RTOP covers research in a diverse array of areas that are critical to future NASA space systems. The objective is to develop advanced technologies relevant to NASA applications in the areas of computer science, data systems, photonics, science sensors, control systems, robotics, and artificial intelligence, which will provide new capabilities and/or greater performance over the current state-of-the-art. Computer science research will demonstrate an easy to use and inexpensive cataloging technique to facilitate software reuse and retrieval. A versatile tool named 'HiLite' is being developed to do this by integrating the technologies of hypermedia, graphical user interface, knowledge engineering, and object-oriented data base management. Data Systems work

will develop application specific electronic neuroprocessor building blocks that will be used to demonstrate real-time functionality of neuroprocessing via a vehicle health monitoring application for the Space Shuttle Improved Auxilliary Power Unit. Photonics work will develop InP based optoelectronics integrated circuits (OEIC) for integrated optic spectrometers, fiber optic ring sensors, optical disk read/write heads, and integrated transmitter/receiver applications. Sensors research will develop unique wavelength semiconductor lasers for injection seeding of solid state lasers. Other research will produce high temperature superconducting devices with optimized microwave response properties for NASA applications such as advanced sensors and low-loss microwave components. Control research will produce several advanced technologies. New computational design tools will be developed to reduce the time and cost required to design and test spacecraft control systems. Advanced metrology concepts with nanometer level performance will be demonstrated for applications like optical space interferometers. An advanced star tracker concept will be developed for real-time autonomous spacecraft attitude determination. System identification and adaptive control research will develop techniques and software to enable automated monitoring of system performance and robust control system self-tuning, and autonomous compensation of dynamic uncertainties and/or spacecraft configuration changes. Robotics research will develop long range technologies in the areas of: automated surface inspection techniques to detect and classify flaws and monitor changes in space structures; complex telerobotic work events and conditions using special graphic formats and displays; microrover navigation sensing and control strategies that can be applied to planetary exploration missions; and mobile robot architectures with low power requirements that provide real-time goal directed performance. Artificial Intelligence research will develop new technology in two areas. Selective monitoring work will achieve designs of AI-based systems to provide focus of attention and anomaly detection capabilities in support of mission operations performing real-time monitoring of space platforms. AI for software reuse work will develop techniques for searching, navigating, and database updating in hypermedia systems.

**W93-70092****(72) 506-59**

Lyndon B. Johnson Space Center, Houston, TX.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

J. W. Sunkel 713-483-8591

The first objective is to develop and assess guidance, navigation, and control concepts, techniques, and design methodologies to provide needed capabilities for full and cost-effective utilization of current and future space systems. Methodologies for cost-effective development, implementation, and verification of control capabilities will also be evaluated. Technology needs will be addressed across interfacing space elements including the Space Shuttle, Space Transfer Vehicle (STV), Manned Maneuvering Units (MMU), free-flyers, aeromaneuvering planetary and earth return vehicles, and the Space Station Freedom. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. The second objective is to develop redundant mechanism architectures and control strategies for robotic manipulator systems which incorporate the ability to transparently absorb drastic mechanism, sensor or control failures and maintain stable end-point trajectory control with minimum disturbance. The third objective is to develop and evaluate concepts and guidance for designing informative, reliable and usable intelligent systems to support human tasks in real-time operations. This element is providing a series of interim products to guide the design of intelligent support systems and their user interfaces for effective information management, for use by intelligent system prototypes and industry and aerospace developers of advanced operations software. The fourth objective is to identify and research solutions to the specific problem areas of supporting Mission and Safety Critical (MASC) software for extremely large, complex, distributed systems such as SSFP, and the Lunar/Mars missions which must evolve and operate ultra reliably, non-stop over many years. Current software engineering

capabilities are not deemed sufficient at this time to support these missions in a safe and cost-effective way. The system software architecture and the features required for such systems is specified as well as the corresponding ground monitoring for such systems and the unique tools required for developing them. These advancements are assembled into a 'test bed environment' complete with expertise to demonstrate the technology; consult on its application; serve as a focal point for disseminating knowledge of the technology; serve as a referral point to analyze software engineering advancements; and provide leadership and an example in the use of the new technology. The project also represents NASA's interest in national and international standards organizations such as the ARTEWG, Joint Avionics Working Group (JIAWG), National Institute of Standards and Technology (NIST), Information Resource Dictionary System (IRDS), Ada computer language, etc. The approach is to address the total scope of the MACS problem which includes the life cycle support for operational systems software. A testbed of multiple clusters of processors was developed and the concepts of parallel processing and distribution were analyzed. In FY-92, the work of identifying the issues and requirements of all of the component operational subsystems such as the kernel, the policy and monitoring systems, the command interfaces, the reconfiguration and fault tolerance handling, and the ground monitoring systems was documented and represented in scenarios. The prototype object management and library management required for supporting the semantic models required for these systems was delivered. In FY-93 these subsystems will be specified and a large number of demonstrations of the scenario will be developed. Future work will investigate 'fine grained' distribution where the objects are broken up into very small elements for enhancing the safety and mission critical objectives. A three-level fault tolerant manipulator mechanism testbed with duality in the joint servo motor modules, parallel structural architecture, and adaptive controller technology that can react to disturbances/failures and continue the operations will be developed.

## Human Support Research and Technology

### W93-70093

(21) 506-71

Ames Research Center, Moffett Field, CA.

#### HUMAN SUPPORT RESEARCH AND TECHNOLOGY

W. Berry 415-604-4930

The overall objective of this RTOP is to create a new technology base in advanced life support systems and extravehicular activity (EVA). The approach will be a coordinated research activity among industry, universities, and NASA in space suits, chemical processing, Portable Life Support Systems (PLSS's) and sensors. The objectives of the Space Suit Technology Element are to understand the requirements for advanced pressure suits and to demonstrate suit elements and assemblies. These objectives will be met using a combination of in-house and contracted design, fabrication, and testing. The results of this work will be applicable to pressure suits for both current and future flight programs. The objectives of the Chemical Processing Element are to develop new physical/chemical process technologies for air revitalization, water reclamation, and solid waste management that will provide the basis for advanced integrated, closed-loop life support systems. The approach is based on laboratory evaluation of new concepts, system trade studies, test stand and testbed evaluations, and state-of-the-art process modeling for use in space platforms, transit vehicles, and habitats. The objectives of PLSS's are to conceive, demonstrate, and characterize new concepts. These objectives will be met using a combination of in-house and contracted experiments, design, fabrication, and testing, beginning with applied

research and ending with demonstrable prototypes. The results of this work will be applicable to portable life support systems for future flight programs. The objective of the Advanced Sensor Element is to develop technology for chemical environmental systems monitoring using ion trap mass spectrometry and expert systems. The approach will focus on enhancing the capabilities of a commercial ion trap mass spectrometer through the development of advanced hardware and artificial-intelligence-based control strategies. This technology will be applied to life support system monitoring, ecosystems monitoring, atmospheric chemistry research, and aircraft exhaust analysis. The objective of the University Research Element is to make universities an integral part of the NASA life support technology development process. The approach will be to provide support to university collaboration through formal solicitations, a NASA Research Announcement (NRA), and consideration of unsolicited proposals.

### W93-70094

(10) 506-71

National Aeronautics and Space Administration, Washington, DC.

#### HUMAN SUPPORT RESEARCH AND TECHNOLOGY

Samuel L. Venneri 202-453-2760

This RTOP provides support for the National Academy of Sciences (NAS) Commission on Behavioral and Social Science (CBASS) Committee on Human Factors. The NAS and its committees provide advice to governmental agencies in solving advanced technology problems. The Committee on Human Factors was established to provide advice on determining the most important theoretical and methodological issues in human factors.

### W93-70095

(55) 506-71

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### HUMAN SUPPORT RESEARCH AND TECHNOLOGY

D. P. Maynard 818-354-8383

During FY-93, Life Support System Analysis (LiSSA) software tool development for physical-chemical life support systems will be completed, including documentation, and sent to ARC and to others as directed by Office of Aeronautics and Space Technology (OAST). The development of a rigorous and comprehensive systems analysis tool for physical-chemical-biological life support systems will continue. JPL will continue to provide systems analysis and test plan support to the System Integration Research Facility (SIRF) at JSC. The subcontract activity on expert technology assessment of extant life support technologies will continue through this FY.

## Space Communications Research and Technology

### W93-70096

(22) 506-72

Lewis Research Center, Cleveland, OH.

#### SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY

J. W. Bagwell 216-433-3502

The overall objective of this RTOP is to provide through research, development, and experimental tests, the devices, components, and subsystems that comprise a suite of enabling technologies for new and improved space communications systems in support of NASA missions, the U.S. commercial communication satellite industry, and other government agencies. To achieve this objective, advanced research and development programs will be conducted in the following areas: electron beam devices and components; solid state devices and components; antenna systems incorporating active and passive phased arrays; digital components and subsystems; RF components and subsystems; and systems validation and testing. Work is performed in-house, on contract, and at universities for the purpose of developing advanced communication technology to enable systems that are frequency



spectrum and power efficient, have longer life, and are low in weight and volume. Technology development is primarily focused on frequencies of 20 GHz to 94 GHz at information rates up to 1 Gbps. This work is expected to result in advanced components and systems for both commercial communications satellites and NASA data relay satellites, science satellites such as 'Cassini', and associated earth terminals.

**W93-70097****(10) 506-72**

National Aeronautics and Space Administration, Washington, DC.  
**SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY**  
 Samuel L. Venneri 202-452-2760

The objective of the Satellite Communications Application Research (SCAR) program is to develop and promote new processes, methods, or techniques that will enable new satellite communications capabilities or services. The SCAR program supports innovative applied research in satellite communications from both the private and public sectors whose implementation in the commercial marketplace will maintain U.S. preeminence. For future NASA planning, the program provides guidance to ensure continuing relevance of NASA's communications program to industry needs and to identify the 'cutting edge' enabling technologies. The work performed will provide U.S. industry with access to NASA-developed techniques or technologies for application in improving satellite commercial service. The research will support key technology R&D to reduce industry risk and expedite commercial communications applications.

**W93-70098****(51) 506-72**

Goddard Space Flight Center, Greenbelt, MD.  
**SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY**  
 Michael A. Krainak 301-286-2646

This RTOP will develop and demonstrate high data rate optical communication technology for future NASA missions in the near Earth environment. The communications link is nominally a Geosynchronous Earth Orbit (GEO)-to-GEO cross link such as that required on the Future Services Growth portion of the Tracking and Data Relay Satellite System II (TDRSS II) and beyond. This RTOP is divided into two portions: (1) System Demonstrator; and (2) Advanced Components. The communication System Demonstrator will be capable of 650 Mbps return and 50 Mbps forward data rates. Emphasis is placed on small, low mass, low power dissipation terminals, which are capable of relaying high rate digital data with low bit error probability. The subsystems will be built to form fit and function requirements with space traceable component designs. The optical communication system will utilize a high power (greater than 1 W) 0.8 micron wavelength AlGaAs semiconductor laser system which will transmit digital data using a four slot pulse position modulation format. These devices will be hybrid integrated with a high speed, high current electronic driver circuit to achieve the required output power and data rate. This unit will be integrated into a small, space traceable optomechanical package which will provide a collimated, diffraction limited beam. Direct detection wide band receivers which use silicon avalanche photodiodes with hybrid integrated pre-amplifiers will detect the incoming intensity modulated signal. Bit synchronizers which have the necessary sensitivity, bandwidth, and low power dissipation will be developed at the LeRC and will be integrated into the system for end-to-end testing. The Advanced Component portion is developing a very high power (greater than 5 W) and data rate (greater than 2 Gbps) laser transmitter and receiver near the 1 micron wavelength. Because of the potential for very large transmitter power levels at this wavelength, this approach may ultimately offer important system level advantages (e.g., size, weight, pointing accuracy requirements, and cost). The NASA Vision 21 Strategic Plan, January 1992 states the following: 'The Communications and Data Systems effort must meet the quantum jump in data rates from spacecraft...' and 'the dramatic increase in requirements of the Hubble Space Telescope, Compton Observatory, UARS, Space Station Freedom, EOS, AXAF...'. Additional high data rate requirements will be incurred from the introduction of High Definition Television (HDTV) cameras on NASA spacecraft. The HDTV data rate is 1.3 Gbps. Optical intersatellite

links (ISL's) can potentially provide a high data rate transmission capability with small terminals, high reliability, and freedom from interference. Optical intersatellite link advantages are accrued from the laser's high operating frequency, efficiency, and smaller physical size. The principal advantages are as follows: greater bandwidths, smaller beam divergence, smaller antennas, and reduced overall system weight and power dissipation. Communications systems operating at optical wavelengths have the additional advantages of low probability of interception and a high resistance to interference. This specific TDRSS II application provides the near team focus for the systems technology being developed within this RTOP. (The lasers and receivers developed under this RTOP can also be used in coded laser ranging and lidar remote sensing applications such as ARISTOTLES, GLAS on EOS, LASE, and Lunar Observer.)

**W93-70099****(55) 506-72**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY**  
 T. Jedrey 818-354-5187

The objective of this RTOP is to develop and demonstrate communications technology to meet future NASA needs and to transfer that technology to potential users, both in NASA and U.S. industry. The RTOP has four basic components. The first component is the Acts Mobile Terminal. The objectives of this program are as follows: (1) to develop the advanced high risk technologies and system concepts necessary for a commercially viable mobile satellite communications system at Ka-band; (2) to demonstrate speech/data transmission in the Ka-band land mobile satellite communications channel; (3) to provide a platform for the realization of the longer term goals of mobile, micro, and personal terminal development; and (4) to characterize the Ka-band land mobile satellite communications channel. To meet these objectives, Ka-band fixed and mobile communication terminals will be developed for experimentation with ACTS. This involves the development of multirate speech codecs, robust multirate modems of the communications channel, transceivers, and medium gain, steerable, low profile vehicular antennas. The second component is Optical Communications. The objective of this program is to develop optical communications transceiver technology for use on future NASA spacecraft. The short-term focus of the program is on the development of an Optical Communications Demonstrator (OCD) laboratory system which integrates all the key ingredients of a spacecraft transmitter terminal. These ingredients include transmit/receive telescope, coarse telescope pointing, transmit laser, and fine beam control pointing. The elements will be integrated into a full-sized terminal called the OCD instrument and will be supported by three ancillary systems: (1) the OCD Ground Simulator; (2) the OCD Controller/Power Supply; and (3) the OCD Test Support Equipment. The third component is the Mobile Satellite Communications Technology. The objectives of this program are to develop a Low Earth Orbit (LEO) mobile satellite terminal testbed and use it to carry out communications system performance evaluation through the proposed LEOEX payload on the first NASA COMET mission planned for launch in early 1993. This L-band mobile terminal will be designed and implemented by JPL using the existing terminal originally developed under the NASA Mobile Satellite-X (MSAT-X) Program. The LEOEX payload, which is currently under construction by Motorola in conjunction with the Space Communication Technology Center of the Florida Atlantic University, may have to be modified in order to accommodate other signal formats pertaining to other proposed LEO systems. It is anticipated that this testbed facility will be made available to all industry partners interested in the performance assessment of their respective systems. The fourth component is the High Temperature Superconductor Space Experiment 2 (HTSSE 2). The objectives of this program are as follows: (1) to complete the testing of the breadboard (BB) HTSSE 2 low noise X-band receiver subsystem for delivery to the Naval Research Lab in 1993; (2) to iterate the BB design if necessary and hold a design review; (3) to fabricate all modules and housings for the three flight units; (4) to assemble and test all modules; (5) to integrate all JPL modules (filter and low noise amp) along with those delivered by NASA LeRC (mixer

and oscillator) into the three flight housings; and (6) to deliver the final units to the Naval Research Lab for their evaluation for flight on the HTSSE spacecraft. It is assumed that Code R will fund NASA LeRC to complete all necessary hardware (mixers and oscillators) developed by LeRC for this project.

## Hypersonic Research and Technology

**W93-70100**

**(21) 506-73**

Ames Research Center, Moffett Field, CA.

### **HYPERSONICS RESEARCH AND TECHNOLOGY**

M. J. Green 415-604-5595

The overall objectives are to advance fundamental understanding of basic physical and chemical processes and to develop predictive capabilities for analysis and design optimization of advanced airbreathing hypersonic vehicles. A synergistic interplay between computational, ground-based experimental, and flight research will be used to validate the technology. These efforts provide the prerequisite research and technology developments enabling an improved and validated technology base for application by industry in the development of future generation hypersonic flight vehicles. The approach of this RTOP will be as follows: (1) to develop and validate new algorithms to reliably and efficiently simulate high altitude low density hypersonic nonequilibrium flows and to provide a generic hypersonic data base for accurate characterization and prediction of hypersonic aerodynamic and aerothermal environments; (2) to advance the development of generic research relating to materials and concepts for thermal protection systems and to understand and resolve hydrogen-materials incompatibility issues applicable to transatmospheric vehicles; and (3) to provide a hypersonic experimental database of sufficient accuracy to calibrate/validate the advanced CFD and engineering design codes used in the prediction of aerodynamic, propulsion, structural, thermal, and controls characteristics encountered on future hypersonic vehicles.

**W93-70101**

**(23) 506-73**

Langley Research Center, Hampton, VA.

### **HYPERSONIC RESEARCH AND TECHNOLOGY**

L. M. Couch 804-864-3736

This research includes executing experimental and analytical programs to develop new, advanced technology in all areas of hypersonics: aerodynamics and aerothermodynamics; propulsion; materials and structures; guidance and control; and systems analysis and multi-disciplinary integration. In addition, supporting the advances in these areas is research aimed toward the development of advanced test techniques, test support methods, and measurement technology. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. Results of this research will enable the development of efficient, viable hypersonic vehicles of all types, including reusable launch vehicles (both single and two stage) and cruise vehicles.

## In-Space Technology Experiments

**W93-70102**

**(21) 506-74**

Ames Research Center, Moffett Field, CA.

### **IN-SPACE EXPERIMENTS**

M. Kliss 415-604-5573

Artificial membranes are used in several technologies currently under advanced development for human life support in space. Such technologies will allow faster and less expensive separations of life support materials in hypogravity, for example, of water from gases or of ions from water. The customer for these technologies will be advanced life support systems on space platforms, in transit vehicles, and in surface habitats. The objective of the Permeable Membrane Experiment is to evaluate the behavior of artificial membranes in microgravity, using the Space Shuttle as a research platform. The approach is to evaluate various kinds of membranes, including those with surfaces that range from hydrophilic to hydrophobic and pore sizes that result in membranes that are permeable, semi-permeable, or selectively permeable, for their ability to control gas, water, and ion flows in microgravity.

**W93-70103**

**(22) 506-74**

Lewis Research Center, Cleveland, OH.

### **IN-SPACE TECHNOLOGY EXPERIMENTS**

O. D. Gonzalez-Sanabria 216-433-5252

The In-Space Technology Experiments Program supports the definition and development of flight experiments to evaluate and validate advanced technologies for future space systems. This RTOP addresses the technologies conceived and developed under industry independent research and development. The Lewis Research Center currently manages industry/university (I/U) flight projects in three technology themes: power systems, propulsion and propellant management, and human support. Included are four I/U flight projects: Tank Pressure Control/Thermal Phenomena (TPCE/TP), Boeing Aerospace/LeRC; Vented Tank Resupply (VTRE), Martin Marietta; Sodium-Sulfur Cell Technology (SSCT), Space Systems/Loral; and Risk Based Fire Safety (RBFS), University of California at Los Angeles (UCLA). TPCE will obtain video and numerical data on the physics and thermodynamics of jet induced fluid mixing for pressure control of subcritical fluids and the thermodynamic mechanism of self pressurization in low gravity. Flight results are of direct relevance to space based fluids and thermal systems and directly applicable to pressure control technology for long term storage and transfer of cryogens in space, and supports transportation and exploration missions. VTRE will acquire video and numerical data on the effectiveness of a capillary vane device to retain fluid in a low gravity environment. The results will provide data for the design of future space based cryogenic and storable fluid systems required for SSF, orbital propellant depots, and spacecraft for planetary exploration programs. SSCT will examine the effect of microgravity operation in critical areas affecting cell performance and validate the design methodology for thermal control, charge/discharge control, safety and spacecraft integration. The results will validate the technology and support design of future spacecraft power systems. RBFS will develop an in-space combustion experiment to acquire data necessary for unique, quantitative risk assessment of spacecraft fire safety. The data will aid the development of improved, efficient, and cost effective fire protection techniques in the operations of SSF and other advanced spacecraft.

**W93-70104**

**(23) 506-74**

Langley Research Center, Hampton, VA.

### **IN-SPACE TECHNOLOGY EXPERIMENTS**

J. F. Creedon 804-864-6033

This work is expected to complete the design and initiate the development of the Jitter Suppression Experiment and the Mid-Deck Active Controls Experiment (MACE); to conduct a reflight of the Mid-Deck 0-Gravity Dynamics Experiment (MODE); and to complete the design and initiate development of the Joint Damping Experiment. Contracted efforts will be conducted on the work for MODE, and to initiate the design and development of the Joint Damping, Jitter Suppression, and the MACE experiments.

**W93-70105**

Goddard Space Flight Center, Greenbelt, MD.

**(51) 506-74****IN-SPACE EXPERIMENTS**

R. McIntosh 301-286-3478

This RTOP has two objectives. The first is to complete the Heat Pipe Performance (HPP) flight experiment, support the flight, complete the data analysis and generate a final report. The HPP is designed to provide data on the operation of heat pipes which are spinning in microgravity. Several types of pipes with various amounts of working fluids will be tested. The pipes will be spun at various rates to simulate g levels from near zero to one g. The experiment will be operated in the mid-deck of the Shuttle. The crew will be involved in operating the experiment, gathering data and providing their insight in performing the experiment. The data obtained will be useful to industry in developing the next generation of communication satellites, many of which will be spinners. The data will also be potentially useful to the manned Mars mission and to the Lunar base where gravity levels are much lower than here on earth. The second objective is to perform Phase B studies for two IN-STEP flight experiments. The first is the Liquid Motion Experiment (LME) which is intended to study the behavior of fluids sloshing in spherical and ellipsoidal shaped tanks. This will also be a mid-deck experiment which will take advantage of the capabilities of the crew. The LME will provide data on the effects of inertial waves in the fluids which cannot be easily studied on earth because gravity is so much stronger than the forces in inertial waves. The data from the LME will benefit designers of propulsion and active thermal control systems for future flight programs. The second IN-STEP Phase B study will focus on the design of an experiment to validate an advanced active thermal control system which will make use of an enhanced condenser surface which can increase significantly the condensation heat transfer coefficients of the system. The experiment is called the Two Phase Flow (TPF) experiment. It will be flown as a Hitchhiker payload in the Shuttle bay and use ammonia as the working fluid. The results of this experiment will benefit many future flight programs which need active thermal control systems.

**W93-70106**

Marshall Space Flight Center, Huntsville, AL.

**(62) 506-74****IN-SPACE TECHNOLOGY EXPERIMENTS**

W. L. Breazeale 205-544-0567

This RTOP covers the following experiments: Emulsion Chamber Technology (ECT), Optical Properties Monitor (OPM), and Hydrogen Maser Clock (HMC). The goals of the ECT are to assess the radiation background encountered in emulsion detectors in orbits up to 400 km; develop or modify emulsion techniques as necessary to allow optimum use of the emulsion method in space, assess the effect of large amounts of shielding depths not yet measured in space flight; and provide dose vs. depth data to computational groups at NASA currently involved in radiation dose assessment in space. University of Alabama at Huntsville will design, build, and analyze the data from ECT. MSFC will supply environmental requirements, perform environmental tests and coordinate Space Transportation System (STS) integration. ECT will be the forerunner of dosimeters for use on the Space Station. The OPM will provide the requisite data for understanding the space environmental effects on materials and the mechanisms of these interactions. This knowledge will lead to development of improved materials and coatings while improving the accuracy of ground facilities and procedures for testing materials. OPM will be designed, built, and tested by a small business firm. MSFC will provide project management and technical oversight. The OPM can be used by the optics and thermophysics communities as a reliable testbed for in-space materials investigations. The objective of the HMC is to understand the in-space performance and systematic characteristics of a very high stability Hydrogen Maser Clock system intended for long-term continuous operation in space. This maser will be optimized for space flight and long-term stability and represents the state-of-the-art in frequency standards (or clocks). It incorporates the essential features of terrestrial hydrogen masers that have frequency stability of a few parts in  $1 \times 10^{16}$  (exp -16) for intervals of several hours. Smithsonian Astrophysical

Observatory (SAO) will design, develop, build, and functionally test the HMC. MSFC will provide project management, technical oversight, environmental testing, and coordination with ESA (spacecraft) and GSFC (laser ground station). Development of a highly stable space clock is the linchpin for several general relativity programs as well as very long baseline interferometry. Other applications include extremely high precision tracking and navigation systems.

**W93-70107**

Lyndon B. Johnson Space Center, Houston, TX.

**(72) 506-74****IN-SPACE TECHNOLOGY EXPERIMENTS**

K. E. Henderson 713-283-5307

The objectives of the In-Space Experiments Program (IN-STEP) is to define and develop space technology experiments that support critical technology needs. Currently the program consists of experiments addressing improved understanding of glow emissions from spacecraft and an experiment to evaluate the performance of electrochemical cells in a low-G environment. The objectives of the Experimental Investigation of Spacecraft Glow (EISG) experiment is to study and characterize glow emissions in the ultraviolet, visible and infrared wavelength regions, and determine how these emissions vary with orbital altitude and spacecraft surface temperature. In the approach of the EISG, high-intensity glow emissions will be produced on a sample plate that will be viewed with a visible imaging spectrometer, an ultraviolet spectrometer and infrared detectors. Glows of different intensities will be produced by the natural atmosphere, thruster effluents and nitrogen released above the sample plate. After completion of the experiment and the data is reviewed by the scientific community, operational procedures and design guidelines can be baselined to reduce glow effects on future missions. The electrochemical experiment, has as its objectives, the investigation of the effects of a low-G environment on the possible improvement of electrolysis cells and to validate the water electrolysis concept for use in future space applications. The approach will be to conduct a shuttle mid-deck experiment with electrolysis cells at various current densities and temperatures over a five-day period. Effects of microgravity or the distribution of liquid electrolyte, the gas/liquid interfaces within the cell and the surface tension of fluids within the pores of the cell cathode, electrolyte matrix, and anode may result in lower cell voltage during operation. An O<sub>2</sub>/H<sub>2</sub> recombiner (fuel cell concept) will maintain a regenerable supply of water to the cell electrode during the experiment. In addition to the performance improvement the work is focused on the validation of the baseline oxygen generation life support concept for the Eight-Man Crew Capacity configuration of Space Station Freedom.

**Interdisciplinary Technology****W93-70108**

National Aeronautics and Space Administration, Washington, DC.

**(10) 506-90****INTERDISCIPLINARY TECHNOLOGY**

Glenn C. Fuller 202-453-2790

(505-90-00)

The objective of this effort is to provide for the Resident Research Associateship (RRA) program. The RRA program is administered by the National Research Council of the National Academy of Sciences under contract to NASA.

## Civil Space Technology Initiative Program

## Space Science Technology

W93-70109

(21) 582-03

Ames Research Center, Moffett Field, CA.

**SCIENCE SENSING (REMOTE)**

C. R. McCreight 415-604-6549

The primary objective of this activity is to develop and characterize advanced infrared (IR) detectors and detector arrays for future space astronomical applications. In this area, the work aims to demonstrate high-sensitivity, low-background performance from arsenic- and antimony-doped silicon impurity band conduction (IBC) detectors, advance the technology of extrinsic germanium IBC detectors, develop the GaAs photoconductor as an alternative to bolometers for 300 micrometer applications, and to continue to develop improved silicon low-noise, low-temperature field effect transistor (FET) readouts for detectors. New astrophysics objectives include demonstration of large-format IBC arrays (up to 256 x 256 elements), and development of array technologies for far-IR bolometers. New additional objectives for FY-93 are: (1) application of modern materials technology toward development of novel pyroelectric IR detectors optimized for operation at temperatures characteristic of passively-cooled systems, around 100 kelvin; and (2) development of a robust ionizing radiation detector for ambient temperature applications on planetary surfaces (elemental analysis) or remote platforms (radiation measurements). The approach is to carefully characterize Si:As and Si:Sb IBC arrays, in 10 x 50, 58 x 62, and 128 x 128 formats; to develop means of producing high-quantum efficiency Ge:B IR detectors by ion-implantation; to characterize next-generation ultra high-purity GaAs produced by epitaxial techniques; and to design and develop new 'alternate substrate' 1.5 K FET's for extrinsic Ge detectors. Additionally, antenna-coupled microbolometer array architectures will be investigated, and exploratory large-format (30 micrometer pixel) IBC arrays will be tested. A stack of lithium-drifted silicon detectors will be developed, with appropriate background rejection techniques, for gamma-ray applications. The pyroelectric detector element will be pursued via a thorough survey of the literature, and development of prototype devices using selected low Curie temperature materials.

W93-70110

(23) 582-03

Langley Research Center, Hampton, VA.

**SCIENCE SENSING (REMOTE)**

F. Allario 804-864-6027

The objective of this program is to develop all solid-state components for versatile active remote sensors supporting high-flying aircraft and space-based earth science investigations in atmospheric dynamics and chemistry. The most important of these sensors are Light Detection and Ranging (LIDAR), Differential Absorption Lidar (DIAL), and Doppler Heterodyne Systems. This research and technology program has been structured to approach these challenges in the areas of laser materials research, detector materials research, laser transmitter design and development, discrete and array detector design and development, lifetime and efficiency improvement through in-house, university grant, and industrial contract efforts. The remote sensors and detectors developed as a result of this effort will be utilized by atmospheric and space scientists for global measurements of atmospheric gases and aerosols (including ozone-related and greenhouse gases), for remote measurement of global atmospheric winds, and for gravitational, metrological, and interferometric measurements.

W93-70111

(51) 582-03

Goddard Space Flight Center, Greenbelt, MD.

**SCIENCE SENSING (REMOTE)**

Henry H. Plotkin 301-286-6185

Technologies are being developed for precision distance determination on space platforms, between platforms, and between

space, lasers, and ground targets. These include advancing space-based laser transmitter and receiver capabilities, and incorporation in system test beds. Objectives are to support the Geoscience Laser Altimeter System (GLAS), the Lunar Scout, Global Topographic Mission (GTM), and Dynamics of the Solid Earth (DOSE) projects and stellar interferometer missions in orbit and on the lunar surface.

W93-70112

(55) 582-03

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SCIENCE SENSING (REMOTE)**

V. Sarohia 818-354-6758

The Science Sensing (Remote) RTOP focuses on development of advanced submillimeter wave sensing and infrared technologies for future NASA missions. The objective of the Office of Aeronautics and Space Technology (OAST) Submillimeter Wave Sensors Program is to develop space-qualifiable components required for submillimeter wave heterodyne receiver systems and to accurately characterize their performance. Performance goals include extending technical capability to higher frequencies (1200 GHz in the near-term, 3000 GHz in the far-term), improving sensitivity an order of magnitude, and developing a viable array technology. The research and development effort is targeted at components to enable technology demonstrations for the NASA submillimeter wave astrophysics missions (Submillimeter Intermediate-class Mission, Large Deployable Reflector) and the Microwave Limb Sounder (EOS-MLS) for Earth remote sensing missions. To achieve the above goals, the submillimeter wave sensing program will develop key technologies in the following five subelements: (1) superconducting mixers - high-sensitivity, heterodyne mixers are required to carry-out astrophysics missions. SIS tunnel junction mixers will be developed, which have been identified as the best approach to achieve the required performance (the mixers operate at physical temperatures of 4 K); (2) solid state local oscillators - oscillators delivering 50 to 100 microwatts of power will be developed using multipliers or solid-state fundamental oscillators (planar varactor diodes will be developed for the multipliers); (3) receivers - the objective of this element will be to optimize the mixer mounts to provide performance closer to the needs of the SMIM instruments (in particular, the mounts will be optimized for 10 percent bandwidth, double sideband operation, and a broad bandwidth IF from 8 to 12 GHz); (4) focal plane mixer arrays - the objective of this task is to develop a focal plane array capability for submillimeter wave heterodyne receivers (focal plane arrays are required for LDR and greatly enhance the data-taking capability in a given period of time); and (5) receivers for earth remote sensing - the objective of this task is to develop receivers to provide the performance required for the EOS-MLS instrument. Subharmonic mixers with planar GaAs Schottky diodes and a very broad IF bandwidth (2-20 GHz) are being developed. These mixers operate at ambient temperatures. In addition to in-house research, a NASA Research Announcement (NRA) program will be put in place involving universities and industries active in the submillimeter sensing area. The JPL infrared detector program develops detector array technologies over a broad spectral range from MWIR (4 microns) to FIR (beyond 200 microns) including broadband thermal detectors. The program consists of the following tasks: (1) GaAs/AlGaAs quantum well and Si-based systems with response to 17 microns for operation above 65 K for the NASA Earth observing missions; (2) Germanium Blocked-Impurity-Band (GeBIB) Detectors to provide infrared coverage (30-250 microns) for astrophysics mission applications; and (3) thermal broadband detectors based on tunneling phenomenon (micro Golay-cell) and high temperature superconducting microbolometers, and low temperature (greater than 10 K) low noise multiplexer, readout and integration concepts for focal planes.

W93-70113

(62) 582-03

Marshall Space Flight Center, Huntsville, AL.

**SCIENCE SENSING (REMOTE)**

J. E. Clark 205-544-6728

The objectives of this RTOP are to develop and demonstrate the operation of a solid state Doppler lidar system which has

greater accuracy in measuring wind velocity, is more reliable and compact, and satisfies the requirements of the Laser Atmospheric Wind Sounder, an OSSA facility instrument for the Earth Observing System. The Laser Sensing Technologies Program is described in detail in the Integrated Technology Plan of March, 1992. This plan was prepared jointly by LaRC, MSFC, and GSFC. The plan describes three focus areas: Doppler Lidar, Differential Absorption Lidar, and Laser Metrology. MSFC has lead responsibility for the Doppler Lidar portion and for coordination and direction of the Centers' collaborative effort. LaRC is responsible for the development of the transmitter laser for this system under direct funding from OAST. A subcomponent, a frequency agile receiver will be developed by JPL under funding through MSFC. MSFC will integrate the components into a Doppler lidar system test bed and conduct characterization and verification tests on the complete instrument.

**W93-70114****(21) 582-04**

Ames Research Center, Moffett Field, CA.

**OBSERVATORY SYSTEMS**

P. Kittel 415-604-4297

The objectives are to develop and demonstrate advanced cryogenic coolers for future space applications. These coolers are required to have a high efficiency, low cost, an extended life, and good temperature stability. The technologies being developed were chosen to increase the usefulness of detectors and of overall sensor systems. Emphasis was placed on technologies that extend mission lifetimes (efficient, durable coolers) and those that extend the available range of operating temperatures (coolers for less than 10 K). These activities blend analysis with component development and include extensive in-house characterization, development, and technology demonstration. In carrying out the program, the work is coordinated with users and maximal use is made of existing facilities and expertise in industry, universities, and government agencies. This program element has three sub-elements. The first is the development of Pulse Tube coolers. These coolers have half the moving parts of Stirling-cycle coolers and no cold moving parts or seals. Thus, they are simpler and more durable than other coolers above 15 K. They are being developed for second generation Earth Observation System (EOS), Orbiting Very Long Baseline Interferometer (OVLBI), and future Geostationary Earth Observation (GEO) applications. The second sub-element is the development of a high efficiency cooling stage to reach 2 K. The best candidate in this range is a magnetic Carnot cycle. This cooler is being developed for Large Deployable Reflector (LDR), Submillimeter Interferometer (SMMI), and Next Generation Orbiting Very Long Baseline Interferometer (NGOVLBI) and its precursors. The cooler would replace the current technology of stored cryogens, extending mission times from less than 1 year to more than 5 years. The third sub-element is to extend the cooling capabilities to below 1 K for cooling long wavelength IR detectors on missions such as LDR and SMMI. The objective is to develop a 3He-4He dilution refrigerator to provide a modular, versatile cooler for temperatures down to 50 milli-kelvin.

**W93-70115****(51) 582-04**

Goddard Space Flight Center, Greenbelt, MD.

**OBSERVATORY SYSTEMS**

S. Castles 301-286-5405

The objective of the Cooler Systems Program is to meet user requirements for cooling detectors and associated electronics, filters, and optics. Such cooling usually provides at least an order of magnitude improvement in performance. Needs will be met by three coolers. The long-life cooler is for the 20-55 K temperature range for long wavelength IR earth science and astronomy missions using HgCdTe detectors, quantum well detectors, and other advanced detectors. Potential users include the Earth Observing System (EOS) and the Advanced X-Ray Astrophysics Facility (AXAF). Payloads requiring liquid helium temperatures will use 20-55 K coolers as an upper stage. A dynamically balanced, two-stage linear Stirling cycle cooler will be developed. The 2-5 K mechanical refrigerator will have a lifetime exceeding five years, for IR, x-ray, gamma-ray, and cosmic ray missions such as the Large Deployable

Reflector (LDR), Submillimeter Interferometer (SMMI), and next generation AXAF and very long baseline interferometry (VLBI) instruments. Cycles with high thermodynamic efficiency will be used to meet the low input power requirements. The long-life vibration-free refrigerator is for the 50-80 K temperature range for use on missions with a fine pointing requirement, such as future Hubble Space Telescope (HST) instruments, space-based VLBI instruments, and interplanetary missions. Gamma-ray instruments such as the Nuclear Astrophysics Explorer (NAE) and GRSO with multiple sensors sensitive to microphonics are also potential users. High speed, miniature turbo-Brayton technology will be used to eliminate vibration.

## Planetary Surface Technology

**W93-70116****(22) 583-02**

Lewis Research Center, Cleveland, OH.

**SURFACE SYSTEMS**

H. W. Brandhorst 216-433-6149

The NASA Civil Space Technology Initiative (CSTI) High Capacity Power Program is intended to augment the SP-100 Power System Qualification (PSQ) being conducted by DOE/SDIO/NASA and is structured to enhance the chances of success for the overall SP-100 nuclear power system development. The program goals are focused on providing component and subsystems options for increased efficiency, growth at reduced weights, and longer lifetime with higher reliability. These goals will be attained by conducting the broad based research and technology program which includes the following elements: systems analysis to guide the research and technology efforts and to identify the pay-offs; conversion systems for nuclear applications; thermal management; power management; systems diagnostics; and environmental interactions.

**W93-70117****(55) 583-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SURFACE SYSTEMS**

C. P. Bankston 818-354-6793

The objective is to develop and demonstrate solid-state thermal-to-electric power conversion technology that meets the long lifetime (10 yr), high efficiency (10 percent or greater) requirements of future high capacity space power systems. The eventual goal is high power density systems that meet mission requirements and minimize system mass, particularly for SP-100 type systems. Specifically, optimization of silicon germanium thermoelectric materials will be completed and potential new higher performance thermoelectric materials will be investigated. The approach focuses on optimizing dopant concentrations for n-type silicon-germanium materials to maximize Seebeck coefficient and on reducing thermal conductivity of n- and p-type silicon germanium by the addition of phonon scattering centers. Also, efforts to identify potential next generation thermoelectric materials for high capacity power generation will continue with the focus on Ge-rich, Sb-rich, and Bi-rich transition metal and rare earth compounds.

## Transportation Technology

**W93-70118****(22) 584-03**

Lewis Research Center, Cleveland, OH.

**EARTH-TO-ORBIT TRANSPORTATION**

L. A. Diehl 216-977-7506

The objective is to provide the knowledge, understanding, and design methodology that will enable the development of advanced high-performance, reusable Earth-to-Orbit propulsion systems with high design margins for extended component service life, and with autonomous ground and flight operations, as well as the development of low cost transportation systems for commercial vehicles. LOX/hydrogen propellant systems and components will receive attention in order to provide the technology base necessary to design and evaluate their impact on future Earth-to-Orbit vehicle size, mass, and cost. Although focused on reusable manned vehicles, the resulting technology advancements and design and development tools will be applicable to a wide range of future engine design options, including expendable or partially reusable cargo delivery vehicles, as well as growth versions and derivatives of the Space Shuttle. This program will provide a national preeminence in space operations, utilization, and exploration to ensure high performance, low cost, and reliability in future transportation systems. It will provide the technology base and engineering design methods to meet the challenging requirements placed on space propulsion systems by the advanced mission and space vehicles envisioned for the future.

**W93-70119****(55) 584-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**EARTH-TO-ORBIT TRANSPORTATION**

L. D. Strand 818-354-6904

The objective of this RTOP is to develop and demonstrate critical technology required to design high-performance, reliable, safe, and cost-effective hybrid rocket motors. The approach is designed to support and complement existing industry/government efforts and combines both experimental and theoretical activities. The former will consist of slab window motor studies using an existing test system that will be expanded and upgraded. The latter will consist of concluding the development of a state-of-the-art hybrid fuel combustion model. The first year slab burner study will be continued and extended, utilizing more sophisticated diagnostic instrumentation. This will include the following: (1) mass spectrometer measurement of the chemical species concentrations in the core flow; (2) laser Doppler velocimetry measurement of core flow velocity and turbulence level; and (3) incorporating infrared windows into the burner to allow radiometric measurement of the fuel surface temperature and thermal gradient profile in the core flow. A second objective is to provide support in defining the payoff potential of advanced technologies and assessing the impact of various technology efforts on meeting the goals of the Earth-To-Orbit (ETO) program.

**W93-70120****(23) 584-03**

Langley Research Center, Hampton, VA.

**EARTH-TO-ORBIT TRANSPORTATION**

W. R. Hook 804-864-6055

The technical objectives of this research are to develop specific technologies which will enhance future launch vehicle performance, operations, or costs. The specific technologies addressed under this activity are the following: to develop and validate advanced manufacturing methods for fabricating low-cost, lightweight Al-Li cryotanks for commercial launch vehicles. The approach for the cryotank manufacturing task is a combined in-house and contractual effort to define potential Al-Li alloys and advanced manufacturing methods for launch vehicle cryotanks. The cost benefits of fabricating near net shape Al-Li cryogenic propellant tanks will be demonstrated. Post processing metallurgical structure will be correlated with mechanical properties. An Al-Li roll forged subscale tank will be fabricated and tested. These results should allow cryotanks which have both reduced weight and reduced manufacturing costs.

**W93-70121****(62) 584-03**

Marshall Space Flight Center, Huntsville, AL.

**EARTH-TO-ORBIT TRANSPORTATION**

J. L. Moses 205-544-1747

The objective of this RTOP is to extend and further develop the earth-to-orbit propulsion technology base in support of current and future space transportation systems, including low cost commercial propulsion technology. The technology described herein encompasses O<sub>2</sub>/H<sub>2</sub>, O<sub>2</sub>/HC (Hydrocarbon), and hybrid propulsion and is directed at developing hybrid propulsion and enhancing liquid engine life, performance, and operability. The activity is divided into three categories: O<sub>2</sub>/H<sub>2</sub> technology acquisition, O<sub>2</sub>/H<sub>2</sub> technology validation, and hybrid propulsion technology acquisition. Technology acquisition activities for O<sub>2</sub>/H<sub>2</sub> systems include analytical model development, performance improvement, cold flow testing, combustor cooling, turbine drive gas generation, control system analysis, materials and process synthesis, and advanced instrumentation development. Technology acquisition activities for hybrid systems include analytical model development and nozzle and feed system performance evaluations. The O<sub>2</sub>/H<sub>2</sub> technology advancements arising from the technology acquisition activity will receive a final degree of verification by testing on a large-scale component, control, and monitoring subsystem or on the oxygen/hydrogen engine system testbed. Technology Readiness Level 6 is the validation goal. The low cost activity in FY-93 will include the following: (1) hybrid propulsion - to define nozzle erosion and low cost turbopump operation in a 40K thrust motor; and (2) subscale 40K thrust liquid bipropellant combustor test and evaluation to define the characteristics of a system employing a pintle injector with an ablative combustion chamber. Cooperative agreements with industry will provide for Government personnel test support for industry furnished test hardware.

**W93-70122****(22) 584-04**

Lewis Research Center, Cleveland, OH.

**SPACE TRANSPORTATION**

S. J. Grisaffe 216-433-3193

The objective of the Advanced Cryogenic Engines program is to provide the technology necessary to proceed with the development of moderate-thrust (7,500 to 200,000 lbf) liquid oxygen/liquid hydrogen rocket engines for various space transportation applications. These applications include upper stages, near-earth orbit transfer, and Lunar and Mars transfer and excursion vehicles. Expected near-, moderate-, and far-term needs are addressed for both expendable and reusable configurations. The approach includes the following: (1) identification and assessment of technology requirements; (2) identification, creation, and/or validation of design and analysis methodologies; (3) development of materials with required properties, and reliable, cost-effective manufacturing processes; and (4) development and validation of engine and support hardware subcomponent, component, subsystem, and system technologies focused on improved reliability, operational efficiency, wide-range operation, low-cost manufacturing, and improved performance. The overall effort is organized as follows: (1) centered around the Advanced Expander Test Bed (AETB) in which the developed technologies and hardware designs will be validated in a systems environment; and (2) coordinated and integrated with other NASA and Air Force space propulsion programs. The objective of the Nuclear Propulsion Project is to develop and demonstrate technology readiness for safe and reliable nuclear propulsion systems to support piloted and robotic exploration of the solar system. Space Exploration Initiative requirements will drive the definition of candidate nuclear propulsion concepts and these concepts will direct the enabling technology. In FY-93 the Nuclear Thermal Propulsion (NTP) will focus on conceptual design and systems engineering, safety and environment studies, a proactive public information program, and facility definition. This effort is planned to be funded jointly by the Department of Energy (DOE) and NASA. The technology development will be conducted by a team consisting of NASA Centers, national laboratories, industry, and academia. Each



organization will contribute in the areas of their respective expertise.

**W93-70123****(62) 584-04**

Marshall Space Flight Center, Huntsville, AL.

**SPACE TRANSPORTATION**

M. S. Swint 205-544-4060

The objective of the Advanced Cryogenic Engines program element is to provide the technology necessary to proceed in the late 1990's with the development of moderate thrust liquid oxygen/hydrogen (LOX/LH2) expander cycle engines. Studies have shown that propulsion systems needed for the next generation of transfer, excursion, and upper stage vehicles must be highly reliable and achieve high performance within a limited engine envelope. The approach includes efforts focusing on developing and validating engine subcomponent, component, subsystem, and system technologies to address improved performance, high reliability, operational efficiency, reduced cost, and engine health management. The essential technology tool of the program is the Advanced Expander Test Bed (AETB). The testbed will reproduce the key operating conditions of an advanced cryogenic engine in a flexible and realistic way. It will provide a mechanism for validating the high pressure expander cycle concept and its advanced component technologies. It will also provide a means for developing and validating system interaction, transient, dynamic and steady-state models and health monitoring techniques. The advanced engines that will be developed based on this technology program, will satisfy multiple users needs including: the commercial launch industry's need for high energy upper stages providing increased payload capability; the National Launch System's (NLS's) need for a high energy upper stage providing high performance orbit insertion and transfer capability, and the science/exploration community's need for high performance transfer stages and descent/ascent vehicle capability.

## Space Platforms Technology

**W93-70124****(22) 585-03**

Lewis Research Center, Cleveland, OH.

**EARTH-ORBITING PLATFORMS**

H. W. Brandhorst 216-433-6149

The objective of this program is to conduct a ground test and evaluation of the design and performance of a complete 2 kWe Solar Dynamic Space Power System. Testing will be conducted at NASA Lewis under simulated conditions of space vacuum and solar input. Major test components of the Solar Dynamic (SD) Ground Test Demonstration (GTD) System include a solar concentrator, a heat receiver with thermal storage, a turbine-alternator-compressor (TAC) assembly, a recuperator, a gas cooler, heat rejection and parasitic load radiators and a load simulator. The TAC and recuperator were previously developed and tested under separate NASA/DOE contracts. Testing and evaluation will be conducted at the component, subsystem and system level. For maximum experimental value, the thermodynamic, optical and heat transfer design will be consistent to the largest extent practical with actual space flight operation. The designs of new components will be scaled from solar dynamic design concepts developed under the Space Station Freedom Program. Testing will include operational conditions of heat-up, start-up, steady-state operation, transient operation, and planned and unplanned shutdown. Sun-shade cycles will be simulated and design and performance will be evaluated under normal and abnormal operation conditions.

**W93-70125****(23) 585-03**

Langley Research Center, Hampton, VA.

**EARTH-ORBITING PLATFORMS**

J. F. Creedon 804-864-6033

The overall objective of the Platform Structures and Dynamics element (i.e., Controls-Structures Integration Program) is to develop and validate the technology needed to design, verify, and operate spacecraft in which the structure and the control interact beneficially to meet the requirements of 21st-century NASA missions. Long-term goals of the effort are as follows: to provide spacecraft dynamic response amplitude reductions of 50 percent, for any input or maneuver, with minimum increase in system mass; to enable the use of wide-bandwidth control structures/interactions (CSI) control systems to achieve several orders of magnitude improvement in control and pointing capabilities; to predict the on-orbit performance of CSI systems to within 10 percent of all amplitude, frequency, time, and stability requirements based on the results of integrated analyses tuned/corrected by closed-loop ground and/or flight test data; to develop unified controls-structures modeling, analysis, and design methods which allow a complete iteration on all critical design variables in a single integrated computational framework; and to develop the capability to validate the performance of flight systems by analysis/ground tests.

**W93-70126****(62) 585-03**

Marshall Space Flight Center, Huntsville, AL.

**EARTH-ORBITING PLATFORMS**

J. F. Macpherson 205-544-5936

The objective of this focused technology program is to develop new and enhanced existing Ground Test Facilities (GTF's) for use as testbeds for advanced controls and structures technology. The GTF's can be used to demonstrate flight readiness of several key control structure interaction (CSI) technologies in the early 1990's, thereby enabling future NASA missions requiring CSI technology to proceed on course. The approach to the research carried out under this RTOP is to develop the CSI Advanced Development Facility (ADF) around the SAFE-1 mast. Novel sensor and actuator hardware has been prototyped and integrated into the ADF to test its effectiveness in achieving the desired control. These prototypes will be tested, modified and improved as required to achieve performance goals. Advanced system identification and control implementation methodologies will be investigated and implemented. The facility further provides a testbed for functional verification of prototype flight hardware. Finally, the CSI ADF will be used to support the CSI Guest Investigator Program. Customers served by these testbed facilities include industry and university investigators wishing to apply and verify modern control theory to pointing and control system design problems like the Hubble Space Telescope (HST), for which the system is presently modeled and configured, and for which considerable flight-data now exist. An additional and significant customer/benefactor of this facilities capabilities will be the mission operations community. When fully integrated through a mission operations interface the facility will be able to emulate flight systems in real-time to support future missions that may experience CSI problems in orbit.

## Operations Technology

**W93-70127****(21) 586-02**

Ames Research Center, Moffett Field, CA.

**AUTOMATION AND ROBOTICS**

H. Lum 415-604-6544

The objective of the artificial intelligence (AI) program is to develop, integrate, and demonstrate the science and technology of AI that will lead to increasing the operational capability, safety, cost effectiveness, and probability of success of NASA missions. AI applications to these missions fall into four basic categories:

intelligent assistance for humans involved in ground and space-based mission operations; tools and techniques to aid in the analysis of scientific and engineering data; autonomous, on-board, fault diagnosis, correction, and control of spacecraft systems; and, capture, integration, and preservation of life-cycle knowledge. The approach of the ARC program has been to develop a world-class internal laboratory in collaboration with an academic/industrial team of leading scientists and engineers. The program includes applied research in planning, scheduling, and design of and reasoning about large-scale physical systems. It also encompasses specific applications projects which have grown as spinoffs from the research work. All of the research and development work is being leveraged by close cooperation with other leaders in the U.S. government, particularly Defense's Advanced Research Projects Agency (DARPA's) Computational Sciences Technology Office (CSTO). Research in scheduling techniques will result in cost savings and more effective use of scarce resources for a variety of Agency missions. Shuttle Orbiter ground processing and Hubble Space Telescope science scheduling are two particular domains that have already benefited from the work. Research in planning methods is focussed on increasing the science return from missions (such as EOS) that require the coordination of knowledge from multiple agents and disciplines. Research in physical systems has centered on better techniques for modeling, diagnosing, and controlling space vehicles, both from the ground and in-flight with a current emphasis on Shuttle and a future focus on Space Station Freedom. Finally, specific efforts in computer-integrated documentation, intelligent assistance for crew-conducted space science, and intelligent scientific instruments, benefit the Space Station Freedom engineering, in-flight life science, and geochemistry communities respectively.

**W93-70128**

**(22) 586-02**

Lewis Research Center, Cleveland, OH.

**AUTOMATION AND ROBOTICS**

H. W. Brandhorst 216-433-6149

The program objective is to provide technology development/transfer for application of knowledge-based systems to the space power electrical systems domain. This is a continuing effort at LeRC to demonstrate cooperative fault management and power scheduling software using appropriate power testbed facilities. The effort to date has resulted in development and demonstration of a prototype fault diagnostic expert system and associated load power scheduler with a small scale electrical power brassboard. The previous year's work included introduction of model-based reasoning approaches in the fault diagnostics and use of a temporal-phased scheduling process to implement both reactive and predictive methodologies within a single scheduling prototype. The current year effort will emphasize the following four technology enhancement areas: (1) extension of an existing model-based fault system to operate on the LeRC Space Station Freedom (SSF) Electrical Power System (EPS) computer network facility; (2) extension of the scheduler to incorporate energy storage management capabilities and better handle resource/activity uncertainties; (3) evaluation of fuzzy methods for SSF battery management; and (4) investigation of methods to support cooperative fault, scheduling and battery systems on SSF network.

**W93-70129**

**(23) 586-02**

Langley Research Center, Hampton, VA.

**AUTOMATION AND ROBOTICS**

J. F. Creedon 804-864-6033

The objective of the activity is to enable efficient, robust, and safe accomplishment of space tasks using telerobotic systems. Available technology and advanced technology developed under the basic research program are integrated to enhance current capabilities and increase operational efficiency. Work concentrates on realistic ground and space tasks in areas of high potential payoffs for telerobotics. First, application of automation and robotics will be approached to increase the scientific productivity of microgravity experiments. Working with Principal Investigators, full

scale experiment mockups will be tested in a simulated laboratory facility to investigate methods to increase the quantity and quality of scientific data. Second, the leading Flight Telerobotic Servicer (FTS) Technology Capture effort to maximize the retention of U.S. space telerobotic technology originating from the FTS program will be investigated. In a joint program with JSC, a software development system and ground testbed at LeRC will be used to develop and test technology for an FTS flight arm at JSC. Third, participation in cooperative efforts with KSC to apply advanced telerobotics sensing and controls technologies to improve the efficiency of shuttle launch processing operations will be performed. This includes methods for automatic inspection, anomaly detection and maintenance under remote supervision. Finally, automated planning and robotic assembly of large planar truss structure and attached fixtures, with application to remote assembly of nonplanar structures and large antennas will be evaluated. Advanced technologies in planning, scheduling, sensor-based control, and expert system monitoring and error recovery will be integrated and tested in cooperation with structural designers in the LeRC Automated Structures Assembly Laboratory. Intravehicular automation and robotics applications will increase the productivity of scientific experiments during the man-tended period of Space Station Freedom (SSF) operations. The FTS technology program, conducted cooperatively with JSC, is the foundation for future U.S. space telerobotic systems, and will result in development of flight manipulator hardware for JSC. An automated inspection system being developed cooperatively with KSC will perform postflight inspection and anomaly detection of shuttle thermal tiles, alleviating a manually-intensive operation and reducing operating costs. Remote assembly of large structures would reduce extravehicular activity (EVA) assembly operations and make large structures feasible in regimes beyond shuttle capability including the Moon and Mars.

**W93-70130**

**(55) 586-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AUTOMATION AND ROBOTICS**

Carl F. Ruoff 818-354-6499

This RTOP consists of two main elements: telerobotics and artificial intelligence. In telerobotics the general objective is to develop, demonstrate, and transfer to users a suite of telerobot system technologies. The program is designed to enable a new generation of missions and is focused on four main space system paradigms: Robotics, Supervisory Control, Teleoperation, and Terrestrial Robotics. In Robotics, the Human-Controlled Microrover task develops Earth Control Station and human interface capabilities required to operate the Go-For microrover with limited communications bandwidth, onboard computational power, and communication latency. The Integrating High-Level State Information in Behavior Control task develops and tests behavior-controlled robots that use high-level state information to achieve goal-directedness. The Behavior Control for Cooperative Agents task develops behavior control techniques for combining multiple independent processes in performing cooperative robotic tasks. The Safety System for Robots Near Flight Hardware task develops a robotic system that utilizes multiple non-contact sensors and other safety mechanisms to provide robust collision prevention. In Supervisory Control, the Remote Surface Inspection task develops and evaluates telerobotics technologies required to perform surface inspection and non-destructive evaluation tasks in space. The Lab Tending Telerobot task develops a prototype ground-remote telerobot system for tending space-based laboratory experiments. In Teleoperation, the Advanced Teleoperation task addresses performing relatively unstructured remote manipulation tasks in space by use of advanced sensing and computer-aided teleoperation devices and techniques. The Telespresence (Exoskeleton) task will develop and evaluate telemanipulation capabilities enabling human-equivalent dexterity for space tasks involving remotely-operated hands. In Terrestrial Robotics, the Ground Emergency Response Vehicle task will develop and apply robotic technologies to reduce the health risk to humans involved in dealing with hazardous materials. The Satellite Test Assistant Robot task will apply telerobotic technology to satellite and



spacecraft environmental testing and assess the cost savings that result. The artificial intelligence (AI) objectives are: to apply and extend mature AI technologies in the areas of monitoring, diagnosis, simulation, design, planning, scheduling, data analysis, software reuse and testing; to develop and demonstrate low-cost technology for addressing current mission operations and scientific data analysis needs; to meet long-term JPL and NASA needs by performing research in model-based reasoning, planning and scheduling, and machine learning. The overall objective of the Ground Data Systems Automation task is to develop and demonstrate AI-based automation technologies that provide multi-mission capabilities for spacecraft ground systems and the Deep Space Network (DSN). The main objective of the Operations Mission Planner (OMP) task is to extend the OMP prototype into an operational domain, the Deep Space Network 26 Meter subnetwork (DSN 26M). A primary objective of the System Test Maker (STEM) task, which addresses space system testing and certification, is to provide knowledge-based assistance in building test cases through the reuse of historical test cases from previous projects. The overall goal of the Design Evaluation Environment task is to construct a prototype design evaluation environment for reasoning about fault dependencies in system design by integrating capabilities from two existing tasks: FEAT at JSC and SELMON at JPL. The overall goal of the Scientific Analysis Assistant (SAA) task is to develop intelligent tools and techniques for use by scientists in preparing, archiving, manipulating, analyzing, and visualizing science data from unmanned planetary spacecraft and other sources. In both telerobotics and Artificial Intelligence, system capabilities will be developed to address the needs of specific users. Close interactions with users will exist through all phases of technology development.

**W93-70131****(62) 586-02**

Marshall Space Flight Center, Huntsville, AL.

**AUTOMATION AND ROBOTICS**

J. E. Clark 205-544-6728

(1) The Space Station Module/Power Management and Distribution (SSM/PMAD) task consists of several autonomous agents that must cooperate to control a power distribution subsystem in the SSM/PMAD breadboard. This task refines modes of operation and provides operating software where expert systems, embedded systems software, and humans must interact for scheduling, planning, fault diagnosis and isolation, load prioritization, and interface control. (2) The Advanced X-Ray Astrophysics Facility (AXAF) Automated Power System task objective is a proof of concept demonstration of an automated AXAF test bed Electrical Power System (EPS). The approach is to transfer the knowledge and experience gained from previous automated EPS projects to the AXAF program and use it to influence the design concepts to be incorporated into the flight and ground systems. The automated EPS concepts will be tested and demonstrated on an actual AXAF hardware testbed. (3) The Optical Plume Anomaly Detection Expert Diagnostic Filter System (OPAD-EDIFIS) task will modify and apply automated data analysis and diagnostic tools under development at Ames Research Center (ARC) to enhance the capability of OPAD data reduction at Marshall Space Flight Center (MSFC). The result would be an autonomous plume analysis data system for liquid rocket engines that can operate without direct human analytical input. Run time for the program is expected to be shortened considerably but the program output is still post test.

**W93-70132****(72) 586-02**

Lyndon B. Johnson Space Center, Houston, TX.

**AUTOMATION AND ROBOTICS**

N. H. Chaffee 713-483-9995

This research and technology proposal has two primary technical areas: (1) telerobotics; and (2) artificial intelligence. The telerobotics project includes surface inspection technology transfer, Special Purpose Dexterous Manipulator (SPDM) emulation, and the Flight Telerobotic System (FTS) technology capture program. The surface inspection project transfers surface inspection technology to be integrated and evaluated in the Automated

Robotic Maintenance of Space Station (ARMSS) testbed under development at Johnson Space Center (JSC). At JSC, the technology will be evaluated in high fidelity Space Station Freedom (SSF) environments that include orbital lighting and realistic damage on SSF Orbital Replacement Units. In addition, computer software associated with this technology will be hosted on computers that model the SSF hardware and software environments. The JSC effort is focussed on developing this technology to operational readiness. The SPDM emulation project provides for the control of the ARMSS robots in a fashion similar to the Canadian SPDM. This emulation is critical to the evaluation of candidate technologies transferred to JSC from the research centers. The FTS technology capture program seeks to capture R&D investment in this flight manipulator. Efforts are planned to characterize and partially certify the arm through a series of tests to be performed at JSC. The FTS arm has been proposed for use in an Orbiter telerobotics flight experiment. The final task involves grasping of freely moving objects, including the development of a system capable of visual recognition, tracking, rendezvous and acquisition of moving objects and touch guided final prehension and grasp stabilization via adaptive control of dynamic interactions. In the artificial intelligence area the objectives are to develop and transfer artificial intelligence technology into manned space operations to improve the quality of monitoring and control of space vehicles (Shuttle and Station), to assist in flight software regression testing, and to reduce the level of manpower required for such activities. Artificial intelligence applications are being developed and fielded in the Shuttle's Mission Control Center (MCC). Expert systems are being developed to recognize and diagnose software problems uncovered during verification testing of Shuttle flight software loads. These applications are being developed by the customers themselves, the Mission Operations Directorate. A Design Evaluation Environment (DEE) which provides methods for automatically generating digraph models from system simulation data is being developed jointly by JSC and the Jet Propulsion Laboratory (JPL). The DEE could significantly reduce the time and manpower required to generate digraph models (which are baselined for monitoring and diagnosis in the Space Station Control Center).

**W93-70133****(76) 586-02**

John F. Kennedy Space Center, Cocoa Beach, FL.

**AUTOMATION AND ROBOTICS**

Tom C. Davis, Jr. 407-867-2780

The objective of this RTOP is to identify, apply, and demonstrate the use of artificial intelligence and robotics technologies to solve specific problems in NASA launch vehicle and payload processing operations at Kennedy Space Center (KSC). The primary project approach is to introduce, within three to five years, automation and robotic applications into those areas that will improve operations efficiency as well as increase safety, quality, and reliability. Production qualified prototype hardware and software are being developed to demonstrate feasibility to the user community. Operational field tests are being performed to validate the use of these technologies and to effect complete technology transfer into the user community. It is anticipated that complete verification and acceptance of automation and robotics technologies in complex ground operations will lead to acceptance of these technologies for space-based operations. This task includes three robotic activities and three activities in artificial intelligence (AI). The Tile Processing Robotic System will inject the orbiter bottomside tiles with rewaterproofing solution (an organic solution that gets burned out every reentry) and inspect the surface of the tiles for damage. It will automate much of the paperwork involved with both operations. The customer for this robot is the Orbiter Mechanical System Division at KSC. The High Efficiency Particulate Air (HEPA) Filter Inspection Robot will inspect the HEPA filters in the ceilings of the payload changeout rooms at Pads A & B for cracks and dislodgements due to launch acoustic vibration damage. The customer for this robot is the Payload Operations Division at KSC. The automated radiator inspection service will inspect the surface of the STS payload bay radiator for damage and delamination while the orbiter is in the Orbiter Processing Facility. The artificial intelligence (AI) portion of this task includes

the production of a distributed architecture shell which will allow the integration of independently-developed intelligent applications into a unified intelligent operations support tool. This tool, an Expert System for Operations Distributed Users (EXODUS), will share resources such as real-time data and access to knowledge bases. Other AI areas of activity relate to the knowledge-based systems which will be included as components to be integrated by this distributed environment. One AI area is the General Planning and Scheduling System (GPSS), which supports the massive scheduling of configurations and resources for processing the Orbiter in the Orbiter Processing Facility. The other is the Knowledge Based Autonomous Test Engineer (KATE) advisory system shell, which models, monitors, and diagnoses various vehicle subsystems. The resulting integrated demonstration environment will facilitate the deployment of intelligent systems for KSC operations support. The primary customer for these activities is the Shuttle Management and Operations Directorate. However, it is expected that the software tools developed by these projects will be transportable to other application areas within KSC.

**W93-70134**

**(21) 586-02**

Ames Research Center, Moffett Field, CA.

**INFORMATION AND COMMUNICATIONS**

H. Lum 415-604-6544

The objective of the artificial intelligence (AI) program is to develop, integrate, and demonstrate the science and technology of AI that will lead to increasing the operational capability, safety, cost effectiveness, and probability of success of NASA missions. AI applications to these missions fall into four basic categories: intelligent assistance for humans involved in ground and space-based mission operations; tools and techniques to aid in the analysis of scientific and engineering data; autonomous, on-board, fault diagnosis, correction, and control of spacecraft systems; and, capture, integration, and preservation of life-cycle knowledge. The approach of the ARC program has been to develop a world-class internal laboratory in collaboration with an academic/industrial team of leading scientists and engineers. The program includes applied research in planning, scheduling, and design of and reasoning about large-scale physical systems. It also encompasses specific applications projects which have grown as spinoffs from the research work. All of the research and development work is being leveraged by close cooperation with other leaders in the U.S. government, particularly DARPA's Computational Sciences Technology Office (CSTO).

**W93-70135**

**(23) 586-03**

Langley Research Center, Hampton, VA.

**INFORMATION AND COMMUNICATIONS**

F. Allario 804-864-6027

The objective is to research new concepts in space data processing and storage. This concept development will result in planning, development, and delivery of technology research and development studies, system feasibility models, and prototype proof-of-concept hardware in support of NASA's mission including advanced aerospace transportation vehicles, space station, co-orbiting platforms, polar-orbiting platforms, and deep space payloads, in the areas of data systems. The approach is to use mission-identified needs and analysis, together with new device and systems technologies in high-speed, space-qualified processors, and high-rate/capacity optical storage systems, to provide an enabling and enhanced system level performance. In particular, elements will be researched and developed through the proof-of-concept phase, and this technology will be delivered for mission projects where appropriate. Individual tasks included are very high speed integrated circuit (VHSIC) multiprocessor technology, erasable optical media, laser diode arrays, multichannel controller, optical disk drive, fiber optic integrated circuit transceivers, and an advanced flight computer.

**W93-70136**

**(51) 586-03**

Goddard Space Flight Center, Greenbelt, MD.

**SPACE DATA SYSTEMS**

D. Dalton 301-286-5659

The objectives of this RTOP are to develop and demonstrate algorithms and applications that can exploit, in Earth orbit, data compression or data analysis that can be programmed and controlled onboard by scientists from their laboratory and received at their workstation. Data compression algorithms will be identified, implemented, and tested on classes of data such as those from the Advanced Very High Resolution Radiometer (AVHRR), the Airborne Visible Infrared Imaging Spectrometer (AVIRIS), the Coastal Zone Color Scanner (CZCS), Scanning Multichannel Microwave Radiometer (SMMR), and Solar Optical Universal Polarimeter (SOU). Customers include EOS Project and Moderate Resolution Imaging Spectrometer (MODIS) instruments. One task was to fabricate and test a GaAs SPARC RISC processor chip using the chip design from an SBIR. Customers include EOS and FUSE for instrument processing. A lossless data compression task was to design, fabricate and test a chip that implements a lossless data compression algorithm. The chip will be designed by the University of Idaho. This chip has been baselined by the Submillimeter Wave Astronomy Satellite/Small Explorer and the Gas Chromatography Spectrometer/Cassini projects. Other customers include EOS. A pipeline processor task was to design, fabricate and test the Ultra-High Speed Data Acquisition system as a cooperative task with the Office of Naval Research. Customers include EOS and other instrument developers. A VLSI design of the pipeline processor data path element will be initiated at the University of Idaho. The lossy compressor task was to develop a quick-look capability for scientific data using source encoding to reduce channel bandwidth by a factor of 4 with selectable factors up to 20, and to develop lossy algorithms using transform coding techniques coupled with lossless source encoding algorithms that will provide optimal performance in the space environment and will be adaptive over the space-to-ground link using VLSI technology. A medium rate network task was to evaluate medium rate network protocols that support data rates between Mil Std 1773 and Fiber Distributed Data Interface (FDDI) capabilities and select one for development in a space qualifiable configuration. A promising implementation would include VLSI techniques using the University of Idaho to fabricate a chip set on a radiation hard process. This task replaces the Configurable High Rate Processing System (CHRPS) Enhanced Testbed which was deleted due to the downsizing of the EOS Project. A CHRPS initial testbed task was to maintain the initial testbed for demonstrating technology developments in a system environment and to provide a mechanism for technology transfer to users.

**W93-70137**

**(55) 586-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**INFORMATION AND COMMUNICATIONS**

John M. Davidson 818-354-7508

The objective and approach of this RTOP is to conduct research and develop technology which will provide NASA with the space data systems and system components needed for future missions. This RTOP is part of the OAST Space Technology Program and will be managed in accordance with its program plan. Data system technology development included in this activity will enhance the ability to make productive scientific use of collected data and enable the deployment of autonomous systems to carry out new and unique missions. The technical objectives of this element are as follows: (1) Advanced Flight Computers: To significantly advance NASA's computing capabilities by developing new general-purpose computer architectures for spaceborne applications. This task will seek architectural solutions that will lead to reduced volume, mass, power, and cost, increased performance, fault-tolerance, long-term reliability, and readiness for flight qualification. These solutions will be based on user needs and availability of state-of-the-art commercial technology; (2) Nonvolatile Random Access Memory: To develop nonvolatile random-access computer memory technology for spaceborne applications which provides high storage density, high data rates, short access times, radiation hardness, and long-term reliability, while also reducing mass, volume, and power consumption; (3) Vertical Block Line Storage Chips: To develop block access (disk replacement) mass storage technology to increase on-board data

handling flexibility. The resulting devices will provide for high storage density, high data rates, nonvolatility, radiation hardness, while also reducing mass, volume, and power consumption. It is especially crucial that the new memory devices require no mechanical (i.e., moving) parts which could compromise the long-term reliability of the system; (4) Digital Autocorrelator Spectrometers: To develop and demonstrate space-qualifiable low-power digital autocorrelator spectrometers using VLSI technology. In FY-93, a 64 channel, 500 MHz bandwidth digital spectrometer will be developed. It will use specially designed CMOS chips which operate at 1 GHz clock rate and reduce DC power consumption; (5) Advanced Image Processors: To develop and demonstrate space-qualifiable special-purpose processors, including the development and demonstration of efficient algorithms for real-time processing of high-rate imaging instrument data streams and the design, evaluation, and demonstration of flight-compatible architectures for implementation of these algorithms; (6) Common Space Multicomputer Operating System: To develop an adaptable, general purpose, fault tolerant, multi-computer operating system, which has a software development environment tailored for flight projects; and (7) Technology Assessments: To support the NASA OAST Data Systems Technology Working Group (DSTWG) in maintaining and upgrading the Civil Space Technology Initiative (CSTI) Data Systems Technology Program Plan.

## Planetary Geology/Geophysics

### W93-70138

151-01-60

Ames Research Center, Moffett Field, CA.

#### SOLAR SYSTEM STUDIES

P. Cassen 415-604-5597

The objective of this RTOP is to contribute to the understanding of the origin and evolution of the solar system, one of NASA's most basic goals. Research is focused on modeling the processes that led to the formation of the planets and other solar system bodies. The results obtained are of both immediate and long-term value to NASA in guiding the planning of future missions to primitive bodies, outer planets, and Mars. The approach of the RTOP is to use theoretical concepts, physical insight, and mathematical modeling together with astronomical and geological data, and experiments relating to aeolian processes, to construct self-consistent mathematical models of planetary processes and structures. Problem areas that are being addressed include: the dynamics and evolution of the solar nebula and protostellar disks in general; the nature of primitive bodies such as comet nuclei; the formation of planets and satellites; the structure and origin of planetary rings; and the interaction of planetary atmospheres with surfaces.

### W93-70139

151-01-70

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### PLANETOLOGY

C. F. Yoder 818-354-2444

This RTOP is a collection of individual planetary geology and geophysics tasks to improve the understanding of: (1) physical processes and compositions on planetary surfaces; (2) solar system formation and dynamics; and (3) the interaction between solid body dynamics and planetary surface features and processes. The scope of studies under this RTOP addresses planets, satellites, the moon, asteroids, comets, and the solar system itself. A variety of disciplines are included in this collection of tasks, ranging from theoretical studies to photogeology, comparative planetology, and data analysis. Many of the geologically oriented tasks feature supplementary studies of analog geologic processes that occur on the earth. Other observationally oriented tasks include laboratory studies of materials that occur on planetary surfaces. The primary

objective of this research is an increased understanding of geologic and geophysical processes in the solar system, with emphasis on both the present characteristics of planetary bodies and their origin and geologic history. These studies include the scientific interpretation of data from past missions and provide support for the planning and instrumentation of future missions. This RTOP supports various computational, experimental, and image processing facilities and capabilities at the Jet Propulsion Laboratory (JPL), including the NASA Regional Planetary Image Facility.

### W93-70140

151-02-00

Goddard Space Flight Center, Greenbelt, MD.

#### EARLY MARS: IMPACT BASINS, CRUSTAL DICHOTOMY, VOLCANIC RESURFACING

Herbert Frey 301-286-5450

The objective was to determine the nature of the crustal dichotomy on Mars, the role played by major impacts in the evolution of this dichotomy, and the relationship of impacts and the crustal dichotomy to major volcanic resurfacing in early martian history. These remain among the fundamental unanswered questions in martian geological evolution, and are relevant to comparative planetary understanding of planetary lithospheric evolution, and to the relative importance of endogenic and exogenic processes in such evolution. The approach was to extend the search for evidence of large impact basins, with emphasis on the cratered southern highlands and especially the south polar region where our current inventory shows an exceptionally low number of large impact basins; to map in detail the multiple ring structure of South Polar Basin and its relation to ridged plains volcanism in this area; to undertake a detailed structural and stratigraphic study of the crustal dichotomy boundary in Acidalia, one of the few places in western Mars where it is well-expressed, and compare this with the boundary further east in Ismenius Lacus and Casius; to assess whether the evolution of this boundary was mostly influenced by endogenic or exogenic events and how this constrains the origin of the crustal dichotomy as a whole; and to determine if additional outcrops of Nplr ridged plains are truly Noachian in age, or Hesperian-age flows so thin that Noachian age craters show through.

## Planetary Materials/Geochemistry

### W93-70141

152-11-40

Lyndon B. Johnson Space Center, Houston, TX.

#### PLANETARY MATERIALS: MINERALOGY AND PETROLOGY

Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the solar system. The specific objective is to learn the pressure, temperature, and chemical composition of distinct mineralogic phases at the time of their formation. Textures, structures, and chemical composition of minerals found in samples of the Moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids), and the Earth will be measured using optical and electron microscope and electron microprobe techniques. Comparison of these results with those from laboratory calibration experiments and theoretical models will lead to pressure, temperature, and history information for parts of solar system objects.

### W93-70142

152-12-40

Lyndon B. Johnson Space Center, Houston, TX.

#### PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY

Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the solar system. The specific objective is to execute laboratory experiments and develop theoretical models

which aid our understanding of the crystallization behavior of rock-forming minerals. Mineral systems similar to those found in samples from the Moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids), and the Earth will be studied experimentally by observing the products of crystallization from experimental charges of known composition cooled under known pressure and temperature conditions. Comparison of these results with the mineralogy of naturally-occurring samples will lead to pressure-temperature and history information for parts of these solar system objects.

**W93-70143****152-12-40**

Goddard Space Flight Center, Greenbelt, MD.

**A LABORATORY INVESTIGATION OF THE FORMATION, PROPERTIES AND EVOLUTION OF PRESOLAR GRAINS**

J. Nuth 301-286-9467

(188-44-57)

The objectives of this program are to: (1) determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species; (2) determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) monitor changes which occur as the result of thermal annealing, hydration, and exposure to cosmic rays. The result will be the characterization of the grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size distribution of clusters as a function of temperature will be monitored via quadrupole mass spectrometer. Objectives 2 and 3 require a separate flow system designed to produce grains rather than clusters and able to produce large amounts of multicomponent smoke. The structure and composition of the initial grains will be determined; infrared and UV/visible spectra of the smokes will be obtained and the particle morphology will be studied via Scanning Electron Microscope (SEM) and Scanning Transmission Electron Microscope (STEM). Samples will be annealed for various times either in vacuo or in liquid/gaseous water and the induced changes studied by the above techniques. Accomplishment of objectives 2 and 3 also require the use of a low T cryostat and 1 MeV proton source to study the interaction of metal/organic ice mantles formed in the interstellar medium with cosmic radiation, and the consequences of such interactions for grains incorporated into the solar nebula. These consequences may include trapping volatile species in silicates and oxygen isotopic fractionation.

**W93-70144****152-13-40**

Lyndon B. Johnson Space Center, Houston, TX.

**PLANETARY MATERIALS: CHEMISTRY**

Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the solar system. The specific objective is to measure the concentration of selected chemical elements (major, minor, and trace) in rock samples of interest. Data obtained supplement, and are often combined with, petrologic studies to yield bounds on thermodynamic parameters at the time of rock origin. Rock samples from the Moon, meteorites (asteroids, comets), cosmic dust (comets, asteroids, Mars) and the Earth will be analyzed using a variety of sophisticated techniques, including neutron activation analysis (NAA) x-ray fluorescence, atomic absorption spectrophotometry, gamma-ray spectrometry, and proton-induced x-ray emission. Relative abundances of trace elements in different samples places bounds on the characteristics of the sources from which the rock-forming materials are derived.

**W93-70145****152-13-60**

Ames Research Center, Moffett Field, CA.

**PLANETARY MATERIALS - CARBONACEOUS METEORITES AND COMETARY ICE ANALOGS**

S. Chang 415-604-5733

The objective of this research is to understand the processes involved in the origin and early evolution of organic matter and volatiles in the solar system through the study of meteorites and

laboratory analogs of cometary ices. The approach taken to meet this objective focuses on the chemical and mineralogical-petrographic analyses of meteorites and laboratory study of astrophysical ices. The abundance, isotopic composition, and distribution of light elements are measured, and the occurrence and distribution of various organic components are determined in meteorites. Systematic searches for elemental, isotopic, and molecular correlations between meteorites and within a meteorite will be made so as to elucidate physical-chemical relationships in the meteorite population. From these relationships will be deduced the nature of the processes that were involved in the origins, accretion, and distribution of these objects and their components in the early solar system. In turn, these processes are modeled by laboratory or computer experiments. Findings from meteorite analyses and model studies are then compared for self-consistency. The structure, morphology, and composition of cometary ice analogs are determined in laboratory studies conducted under simulated astrophysical conditions. Correlations between laboratory observations and astronomical observations of interstellar and cometary ices will be sought in order to understand the nature and origins of the natural materials.

**W93-70146****152-14-40**

Lyndon B. Johnson Space Center, Houston, TX.

**PLANETARY MATERIALS: GEOCHRONOLOGY**

Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the solar system. The specific objective is to determine the absolute time when a particular event, such as the eruption of a volcano or the formation of a large impact crater, occurred. The concentrations of radioactive decay products and the corresponding parent isotopes will be measured in carefully selected rock samples using mass spectrometric techniques. With knowledge of the decay constant (half life) for the radioactive element, and assuming a closed chemical system, the time since system closure may be deduced. Systems currently in use are: K-Ar, Rb-Sr, Sm-Nd, Lu, Hf, and U-Th-Pb. Study of extinct radioactive nuclides, such as Pu, leads to information on the interval of time between the formation of the nuclide and its incorporation into a solid.

**W93-70147****152-17-40**

Lyndon B. Johnson Space Center, Houston, TX.

**PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES**

Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the solar system. The specific objective is to learn about the interaction between the space environment, which consists of meteorites, galactic cosmic rays, and solar particle and electromagnetic radiations. Samples of the lunar regolith offer the opportunity to find variations in the intensity of the environmental factors over geologic time. A variety of approaches will be used. The radioactivity of cosmic-ray produced nuclides will be analyzed as a function of sample depth. Surfaces will be studied using electron microscopes. Etchable heavy element ionization damage tracks will be revealed and studied. Solar wind noble gases will be analyzed mass spectrometrically. Multidisciplinary studies will be performed using selected samples.

**W93-70148****152-20-01**

Goddard Space Flight Center, Greenbelt, MD.

**MICROGRAVITY NUCLEATION AND PARTICLE COAGULATION EXPERIMENTS**

J. Nuth 301-286-9467

(152-12-40; 188-44-57)

Laboratory studies of the vapor-solid nucleation of refractory species have been hampered due to thermal convection. This problem is especially severe for refractory species such as SiO, C, Al<sub>2</sub>O<sub>3</sub>, and SiC which are important in both astrophysics and meteoritics. Well controlled studies of particle coagulation are difficult to perform on earth since larger particles tend to settle out just as the experiments produce aggregates of macroscopic

size. We will construct and test a system which will yield high quality data on the nucleation of refractory materials and also produce a cloud of well characterized particles which would be used to carry out studies of particle coagulation on a number of refractory species aboard NASA's KC-135 research aircraft. We will also characterize the magnetic properties of the Fe-Ni system and the magnetic record contained in meteoritic materials. Refractory vapor will flow from a heated crucible, down a controlled temperature gradient until nucleation is detected via light scattering from the newly formed grains. Particles will be collected in flight and characterized on the ground. Particle size, composition, crystal structure, and morphology will be determined. If the particles produced during the nucleation experiment are uniform, then the end of a nucleation experiment will constitute the beginning of a particle coagulation experiment. Changes in the particle size distribution due to aggregation will be monitored via light scattering and extinction measurements. Because of the short time available in 0 gravity (t less than 25 s) we expect that only nucleation experiments will be possible on the KC-135. Coagulation experiments will await the more extended timescales available during Space Shuttle flights. Magnetic characterization of materials will occur both on the ground and aboard the KC-135 Aircraft.

**W93-70149****152-20-40**

Lyndon B. Johnson Space Center, Houston, TX.

**PLANETARY MATERIALS: COLLECTION, PRESERVATION AND DISTRIBUTION**

James L. Gooding 713-483-5126

The objective was to provide for maintenance of the Lunar Sample Collection under secure, controlled environmental conditions; for the description of samples as new materials are prepared for analysis; for the maintenance records of the status and distribution of lunar samples; for providing lunar samples to approved investigators and for display purposes; for technical monitoring of NASA-funded grants/contracts to Planetary Materials Investigators; for similar functions for the Antarctic meteorite collection, including initial description, processing for distribution to investigators, and maintenance under controlled environment; for dissemination of information on meteorite collection; for staff members' participation in field collection; for the collection of cosmic dust samples using high altitude aircraft; for the characterization of dust particles; for distribution to scientific investigators; for dissemination of information; and for development of curatorial techniques for, and educational use of, materials from the various collections. The operation, which is undertaken by support contractor personnel, is directed by Civil Servant scientists and administrators. The program provides samples and information for about 65 domestic and foreign lunar sample investigator groups, over 100 meteorite investigator groups, and ten cosmic dust investigator groups.

**W93-70150****152-30-40**

Lyndon B. Johnson Space Center, Houston, TX.

**PLANETARY MATERIALS: GENERAL OPERATIONS AND LABORATORY FACILITIES**

Gordon A. McKay 713-483-5041

General operations support a variety of institutional and scientific support tasks at JSC that are considered essential for the conduct of research and for implementation of the Planetary Materials and Geochemistry Program (PMGP). Inhouse support provides for co-sponsorship of conference, laboratory costs required by visiting scientists using existing facilities, and for cost required to operate common laboratory and computer facilities. This plan also provides inhouse laboratory maintenance for the visiting scientist programs of NASA (National Research Council, Lunar and Planetary Institute, NASA Graduate Intern, etc.). A significant element of this RTOP is an annually updated plan for the systematic modernization of laboratory equipment and instruments. The overall plan includes funding from other benefiting NASA and other agency programs. This RTOP also includes JSC expenses for the Lunar and Planetary Science Conference and support for the Lunar and Planetary Institute per JSC-LPI Memorandum of Understanding.

**W93-70151****152-88-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**STUDY OF POTENTIAL MARS OBSERVER - MARS 94, 96****FLIGHT PATH COOPERATIVES**

J. K. Campbell 818-354-5768

The long-range objectives were to provide coordination between U.S. and Russian scientists, and the Deep Space Network (DSN) with regard to radio metric tracking, and to negotiate tracking passes for navigation and science returns, based on technical benefits analyses. The short-range objectives were to perform error covariance analyses to establish benefits to relevant U.S. and Russian science objectives of various DSN tracking modes and data types: Doppler, ranging, VLBI, as well as optical imaging as appropriate; to coordinate these analyses with Russian navigators to obtain agreed-upon results; to understand the capabilities of Russian tracking facility, and assumptions made in analyses; and to analyze Voyager tracking signal acquired by Russian antennas, for assessment of quality. The long-range approach was to represent the Mars 94 mission to the DSN Resource Allocation Board, and negotiate for tracking passes identified by analyses as being beneficial to U.S. and Russian science objectives. The short-range approach was to attend the U.S.- Russian JWG meeting in September 1992; organize kickoff meeting in Moscow October 1992; and agree on scope, content, and assumptions relevant to producing navigation and gravity model error analyses for each phase of the Mars 94 missions.

**Planetary Atmospheres R&A****W93-70152****154-10-80**

Ames Research Center, Moffett Field, CA.

**PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY**

J. B. Pollack 415-604-5530

(196-80-00)

The objective of this RTOP is to determine the properties and physical processes characteristic of planetary atmospheres by means of theoretical modeling and spacecraft and ground-based data interpretation. These properties include their temperature structure, aerosols, cloud layers, gaseous constituents, and opacity sources. The approach of this RTOP is as follows. Emphasis is placed on reducing and analyzing data returned from spacecraft missions, such as Voyager, or preparing for data expected from future spacecraft missions, such as Galileo. However, use is also made of relevant ground-based observations. In addition, the origin and evolution of planetary atmospheres and the outer planets are studied by constructing models that are constrained by relevant spacecraft and ground-based data.

**W93-70153****154-20-80**

Ames Research Center, Moffett Field, CA.

**DYNAMICS OF PLANETARY ATMOSPHERES**

R. E. Young 415-604-5521

The objectives of this RTOP are to model the atmospheres of Venus and Mars and to compare model results with spacecraft data and attempt to understand the dynamical effects of varying planetary rotation rate, solar energy deposition, infrared opacity, atmospheric mass and composition. The approach of this RTOP is to study the dynamics of the atmospheres of Venus and Mars using multi-dimensional circulation models. The coupled momentum and energy equations are solved numerically using combinations of finite difference and spectral methods.

**W93-70154****154-20-80**

Goddard Space Flight Center, Greenbelt, MD.

**DYNAMICAL PROPERTIES OF PLANETARY ATMOSPHERES**

F. M. Flasar 301-286-3071

This RTOP supports advanced data analysis of dynamical properties of the outer planets' atmospheres. Task-01 addresses a comparative study of the zonal mean circulations of the giant planets.

**W93-70155****154-30-80**

Ames Research Center, Moffett Field, CA.

**PLANETARY CLOUDS PARTICULATES AND ICES**

O. B. Toon 415-604-5971

The goals of this program are: (1) to determine the nature and properties of clouds and aerosols on Mars and Titan; (2) to determine the physical and chemical processes responsible for the cloud structures observed on Mars and Titan; (3) to provide comparisons between terrestrial and planetary clouds; and (4) to use computer models to provide a self-consistent framework for determining cloud properties from first principles of physics and chemistry. A generalized planetary cloud computer code was developed which now allows us to approach a large number of problems from a consistent framework. The model is being used to simulate the haze on Titan, as well as dust storms and water ice clouds on Mars.

**W93-70156****154-50-80**

Goddard Space Flight Center, Greenbelt, MD.

**SPECTRAL AND PHYSICAL PROPERTIES OF PLANETARY ATMOSPHERIC CONSTITUENTS**

D. C. Reuter 301-286-2042

(196-41-54; 188-44-57; 464-21-02)

The principle goals of this laboratory program are to measure the spectral line parameters, energy transfer processes and thermodynamic properties of planetary and cometary constituents under appropriate conditions, e.g., temperature and pressure. Accurate laboratory data are critical to proper modeling and interpretation of observations. For example, in the case of lower resolution planetary observations, such as Voyager IRIS (4 cm<sup>-1</sup>), identifications and abundance determinations require laboratory spectra of similar resolution which can be directly compared with the observations. Condensed phases of some molecular constituents may also contribute to the Voyager spectra. The highest possible spectral resolution is required when single features apparent in medium or high resolution Fourier transform spectra (FTS) are composed of more than one molecular transition, and the parameter's frequency, strength, lower state energy, and foreign-broadening must be known for each as input in modeling the atmosphere. For high resolution FTS and heterodyne observations, the need for ultra-high resolution laboratory data is especially critical, since the bandwidths accessible to these receivers are narrow and Doppler line profiles are completely resolved in the observed spectra. A combination of tunable diode laser (TDL), color-center laser (FCL) and FTS laboratory spectra can supply a complete set of line and band parameters anywhere in the infrared and novel techniques such as intracavity laser absorption spectroscopy can provide difficult to acquire information on extremely weak absorption features. Thermodynamic properties at low temperatures can be obtained using recent innovations in pressure measuring technology. In this program, TDL, FCL and FTS spectrometers will be applied to selected vibration-rotation bands of planetary molecular species. A vacuum station that incorporates a spinning rotor gauge, capacitance manometers, and a residual gas analyzer will be used to measure the vapor pressures of a variety of hydrocarbons and sulfides.

**W93-70157****154-60-80**

Goddard Space Flight Center, Greenbelt, MD.

**PLANETARY AERONOMY: THEORY AND ANALYSIS**

R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the neutral atmospheres and ionospheres of the planets in order to identify and interpret the physical and chemical processes governing their behavior, including solar planetary relationships. One of the motivating philosophies is that the study of processes occurring in the atmospheres and ionospheres of the planets provides important insights into the nature of similar processes

operative at other planets (including Earth) but under different parametric conditions and vice versa. The investigations are pursued by analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated. The data is used to determine the various chemical, compositional, dynamical and energetic states of the respective atmospheres and ionospheres, including the transport and deposition of mass, momentum and energy in these regimes. In general, the approach involves the development of empirical descriptions of either global or small scale phenomena using data sets from a variety of spacecraft. These empirical descriptions of the atmospheres and ionospheres are subsequently interpreted using theoretical models developed to deduce the physical and chemical processes involved. Some of the specific phenomena addressed in this investigation include: atmospheric and ionospheric motions on Venus, Jupiter and Earth, interactions of solar wind and/or magnetosphere with atmospheres of Venus and Earth, including modification of transport coefficients by instability processes, solar planetary relationships, comparative planetary atmospheres, etc.

**W93-70158****154-60-80**

Ames Research Center, Moffett Field, CA.

**STUDIES OF CLOUD PROCESSES ON THE OUTER PLANETS**

C. R. Stoker 415-604-6490

(154-30-80)

The objective of this RTOP is to understand cloud processes on the outer planets including the vertical structure of clouds and aerosols in these atmospheres and the physical and dynamical processes responsible for discrete cloud formation. Theoretical studies and analysis of spacecraft data are performed to determine the vertical structure of clouds and how these structures are produced. The effects of cloud microphysical processes on bulk cloud structure in the atmospheres of the outer planets Jupiter, Saturn, Uranus, and Neptune; the manner in which cloud precipitation formation and mass loading of updrafts by condensates affects the dynamics of convective clouds; the life cycles of convective clouds; and the conditions required to initiate moist convection on the outer planets are being investigated. The approach of this RTOP is to use theoretical modeling and analysis of spacecraft data to study the vertical structure of clouds in the atmospheres of the outer planets and theoretical modeling to help understand how this structure is produced. We are developing numerical models of moist convective clouds and incorporating procedures to study the formation and growth of condensate clouds in the atmospheres of the outer planets. We are fitting data derived from Voyager images to radiative transfer models to help understand the vertical structure of discrete clouds on the outer planets.

**W93-70159****154-75-80**

Goddard Space Flight Center, Greenbelt, MD.

**CHEMICAL KINETICS AND SPECTROSCOPY OF PLANETARY MOLECULES AND RADICALS**

L. J. Stief 301-286-7529

This RTOP studies physicochemical phenomena in planetary atmospheres, comets, and related aspects of interstellar matter. Laser spectroscopy, photochemistry, reaction kinetics, and irradiation of mixtures of frozen gases are investigated and properties of atoms, radicals, molecules, and ice mixtures are measured. These experimental results are used to interpret astronomical observations and develop theoretical models. A flash photolysis-resonance fluorescence apparatus with a computer interface for real time analysis yields absolute atom-molecule rate constants. Rate constants and reaction products are determined for atom-radical and radical-radical reactions using a discharge flow system with collision-free sampling to a mass spectrometer. An excimer laser and/or flashlamp is used for photodissociation studies of planetary or cometary radicals. A tunable dye laser is used to detect and study the properties of these radicals. Ice mixtures are irradiated with MeV protons and ultraviolet light; the spectra and vaporization of initially deposited and irradiated films are measured with an FTIR and a mass spectrometer.



**W93-70160****154-90-80**

Ames Research Center, Moffett Field, CA.

**PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS**

W. J. Borucki 415-604-6492

The objectives of this RTOP are to determine the role of atmospheric electrical processes in the evolution of planetary atmospheres and to delineate the electrical and meteorological processes that give rise to the extreme electric fields required for lightning. The approach is to use comparative planetology, i.e., to compare the spacecraft observations with terrestrial observations and theory in order to understand the processes occurring on other planets and to check the applicability of the theories that have been developed to explain terrestrial lightning and atmospheric electricity. Images and other types of spacecraft measurements are analyzed to determine the characteristics of planetary lightning. Laboratory measurements are conducted to measure the parameters needed to interpret the spacecraft data. For example, to convert the brightness of the optical lightning flashes recorded by the imagers to the energy dissipated by lightning and to the production rate of molecular species, it is necessary to make laboratory measurements of the optical efficiency of lightning and to determine the molecular yield per unit of energy dissipated. Theoretical models are developed that allow us to construct a picture of the lightning activity and its effect on the atmosphere for each planet. This picture is then compared to the terrestrial picture and conclusions about the similarities and differences are then drawn. The comparisons lead to improvements in the theories and to requirements for new spacecraft measurements.

**W93-70161****154-95-80**

Ames Research Center, Moffett Field, CA.

**MARS 3-D GLOBAL CIRCULATION MODEL**

R. M. Haberle 415-604-5491

The objective of this RTOP is to further the understanding of the processes controlling seasonal cycles of dust, water, and carbon dioxide that characterize the climate of Mars. While the Mariner 9 and Viking spacecraft missions have provided a good first order definition of the amplitude and phase of these cycles, the processes controlling them remain uncertain. The approach of this RTOP is to numerically simulate various aspects of these cycles using one, two, and three-dimensional climate models. The one-dimensional model is a time-marching boundary layer type model that includes the solar and infrared radiative effects of dust as well as carbon dioxide. It is used to isolate the effects of dust on temperature structure and feedback mechanisms between dust loading and dust raising. The two-dimensional model is a zonally symmetric primitive-equation model with a tracer transport capability. It is used to study the role of atmospheric transport on the water cycle, and the radiative-dynamical feedback effects of dust on the general circulation. The three-dimensional model is used to study the effects of large-scale eddy motions on the transport of water.

**Mars Data Analysis****W93-70162****155-04-00**

Ames Research Center, Moffett Field, CA.

**MARS SURFACE AND ATMOSPHERE STUDIES**

R. M. Haberle 415-604-5491

The objective of this research is to better understand: (1) the nature and variability of the Martian planetary boundary layer; (2) the ability of water molecules on Mars to adsorb onto soil particles in the presence of a carbon dioxide background gas; and (3) the radiative properties of suspended dust particles in the Martian atmosphere. This research is stimulated by NASA's ongoing

planetary exploration program, and the President's recent Space Exploration Initiative. The approach of this effort involves observational, theoretical, and experimental analyses. The observational approach involves further reduction of Viking and Mariner 9 data. The theoretical approach involves use of high speed computer codes to solve complex radiative transfer and fluid dynamical problems. The experimental approach will create a near Mars-like environment to develop new insight into otherwise intractable problems. Each of these approaches makes effective use of the computational and laboratory facilities at Ames.

**W93-70163****155-04-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MARS ATMOSPHERE DUST OPACITY**

T. Z. Martin 818-354-2178

The objective of this task is to seek a new understanding of the global behavior of atmospheric Martian dust by pursuing several tasks that provide improved data on dust opacity. Opacities will be derived from the Mariner 7 flyby using infrared (IR) spectrometer data; opacities will be mapped using Viking IR Thermal Mapper data; and earthbased telescopic measurements from the IR Telescope Facility will be reduced.

**W93-70164****155-20-00**

Goddard Space Flight Center, Greenbelt, MD.

**MARS DATA ANALYSIS**

Jacob I. Trombka 301-286-5941

A number of cooperative programs of Mars Exploration and Data Analysis were undertaken as part of the joint U.S./U.S.S.R. Solar System Exploration Working Group. These programs include an Antarctic balloon flight for calibration of detectors used on both U.S. and Soviet Missions and U.S. Co-Investigator support for the Soviet Mars 1994 Mission.

**W93-70165****155-20-00**

Ames Research Center, Moffett Field, CA.

**PLANETARY DATA SYSTEM**

R. M. Haberle 415-604-5491

The objective of this research is to: (1) provide modeling data to planners of the Mars 94/96 mission to help determine site selection for the landed packages; (2) provide modeling data to the Planetary Atmospheres Node of the Planetary Data System (PDS); and (3) provide a stable center of expertise in the archiving, analysis, and interpretation of planetary ring data obtained from ground-based and spacecraft observations. This research is stimulated by NASA's ongoing planetary exploration program and the need to provide easy access to the data sets that come from it. The approach of this effort involves the use of a general circulation model of the Martian atmosphere to simulate various circulation patterns at different locations, times of year, and dust loadings. The model results can then be used to forecast wind and temperature conditions at candidate landing sites to assess the mobility of the balloon component of the landed packages aboard the Mars 94/96 spacecraft. The same model will be used to provide simulated data to the planetary atmospheres node of the PDS. An additional approach is to acquire, format, and catalog all relevant planetary ring data into a database management system that will provide user friendly access for the planetary community. Each of these approaches makes effective use of the computational and laboratory facilities at Ames.

**W93-70166****155-20-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**U.S. PARTICIPATING SCIENTIST MARS 94/96 - MARS GLOBAL GEODESY**

T. C. Duxbury 818-354-4301

The objective is to solve problems related to the total science objectives of the MARS 94/96 mission using TV imaging observations gathered from the Orbiters, small stations, penetrators, and balloons, and from Orbiter radio occultation and altimetry observations. This research is focused to maximize the science return from the Russian mission for the near-term and long-term U.S. Mars exploration goals and objectives benefitting

the U.S. Strategic Exploration Initiative (SEI) Robotics missions. The scientific objectives are organized into five categories: (1) global geodesy and cartography; (2) surface photometry and thermal inertia; (3) correlative and interdisciplinary studies; (4) Phobos and Deimos; and (5) searches. The objectives within each of these categories share common analysis approaches and utilize observations from the same sets of instruments. This effort will rely heavily on existing capabilities that this proposer has developed and used successfully on previous space missions including Mariner 9, Viking, Voyager and the Soviet Phobos Mission, and in supporting U.S./U.S.S.R. Joint Working Group. The experience gained from these missions would be used to support the definition, instrument development and ground testing, ground data system development, instrument flight testing, science planning, mission operations, correlative data set generations, data analysis, data management, and publications of results for all phases of the mission. To help give focus to this proposal, this investigation would work closely with and through the U.S./U.S.S.R. Joint Working Group for Solar System Exploration and its Implementation Teams for Annexes number 1, 2, 3, 4, and 15, and with the U.S. Mars Science Working Group supporting the SEI Robotic missions.

**W93-70167** **155-20-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MARS 94 GRAVITY**

W. L. Sjogren 818-354-4868

The long term objectives (starts 1995) are to: (1) refine the gravity field of Mars; (2) construct and test interior structure models of Mars using the gravity data; (3) determine Mars spin pole orientation and separate the moments of inertia with a precession rate determination; and (4) determine new masses of Phobos and Deimos. The short range objectives (now through 1994) are to: (1) coordinate with the Russians on their mission design and hardware capabilities; (2) understand their efforts in this field; and (3) suggest to Russians and U.S.A. managers ways to optimize and make this experiment better within its existing bounds. The long range approach is to analyze simultaneous Doppler Radio Tracking of our Mars Observer Spacecraft and the Russian's two Mars 94 spacecraft, as well as surface eggs and balloon and to invert these data for gravity parameters. The short range approach is to: read literature from Russians; write letters to Dr. Akim in Russia; go to meetings where the mission will be discussed; and discuss Mars 94 when Dr. Akim visits JPL for MGN.

**W93-70168** **155-20-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MARS 94 WINDS**

R. A. Preston 818-354-6895

The Mars '94 balloons will be used to measure the winds in the lower atmosphere of Mars. Down-looking cameras onboard the balloon gondolas will likely be the principal instruments used in the wind measurement. Registration of pairs of overlapping images provides information on the horizontal motion of the balloons, and hence, the winds. However, measurements from other instruments are necessary to optimize the image registration process and to interpret the image pair offsets. In addition, the dynamics of the balloon-gondola system must be well understood and Doppler measurements on radio links from the balloons to the orbiters and the Earth may be important to the optimum wind determination scheme.

## Planetary Instrument Definition

**W93-70169** **157-03-50**

Goddard Space Flight Center, Greenbelt, MD.

**PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT**

Jacob I. Trombka 301-286-5941

The objective of the investigation is to develop remote-sensing and in-situ measurement systems for geochemical and geophysical exploration of the planets, asteroids, and comets. These studies will be consistent with planetary exploration programs being developed in the Solar Systems Exploration Program of NASA. Specifically these tasks include instrument development in the fields of x-ray, gamma-ray, neutron, and mass spectroscopy. Both theoretical and experimental studies will be used in these investigative studies. Further studies will include investigation of the affects of the radiation environment in the operation of these detector systems. Prototype detector systems will be constructed and tested in the laboratory environment. Balloon Flights and measurements in environmental chambers will be used to test for space operation. The data obtained can then be used in the determination of detector sensitivity, calibration, and design for planetary space flight missions.

**W93-70170**

**157-03-70**

Goddard Space Flight Center, Greenbelt, MD.

**IMAGING SPECTROPOLARIMETER**

John J. Hillman 301-286-7974

The goal of this investigation is to verify the conceptual design for a novel, versatile imaging spectropolarimeter experiment. Novel aspects of the design include the use of Acousto-Optical Tunable Filters (AOTF's) to provide spectral discrimination and simultaneous polarization. New-technology array detectors will provide spectral imaging in the Short-Wave Infrared (SWIR; 0.8 microns less than lambda less than 3 microns). A PIDDP (Planetary Instrument Definition and Development Program) project conducted at JPL in FY-89 and FY-90 generated quantitative data on AOTF performance and optimal design approaches for such an experiment. Experience gained from that project led to the preparation of the POLARIS proposal for the Cassini Orbiter. The objective is to draw upon the same base of experience and data to construct a proof-of-concept version of such an experiment and to demonstrate its capabilities by using it to make practical observations in the field. Potential platforms of this design concept include compact multispectral cameras for Discovery-class planetary missions and imaging spectropolarimeters for terrestrial remote-sensing.

**W93-70171**

**157-03-70**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ASTROMETRIC IMAGING TELESCOPE**

R. Terrile 818-354-6158

The Astrometric Imaging Telescope (AIT) is an Earth-orbiting spacecraft designed to detect and characterize extra-solar planetary systems. The two instruments of AIT detect planets both indirectly by observing the astrometric wobble of the system star, and directly by imaging the planet. The major objective of the program is to perform the research and development that will demonstrate that AIT is a technically ready and superior candidate for the first space-based mission of the Towards Other Planetary Systems program (TOPS 1). The three centers of activities are the Jet Propulsion Laboratory (JPL) program team, the Hughes-Danbury Optical Systems (HDOS) contractor support team, and the Science team (leader--E. H. Levy, Lunar and Planetary Laboratory). Major tasks of the JPL team are the mission, system, and subsystems designs, and end-to-end performance modeling. HDOS has the unique task of developing mirror metrology and fabrication techniques for the AIT optics. In addition HDOS assists JPL in the spacecraft area. The Science team provides the theoretical underpinnings for the mission, as well as state-of-the-art experience with the instrumental prototypes.

**W93-70172**

**157-03-80**

Goddard Space Flight Center, Greenbelt, MD.

**PLANETARY ORBITAL/FLYBY LASER ALTIMETER**

James B. Garvin 301-286-6565

This Planetary Instrument Definition and Development Program (PIDDP of Code SL) investigation intends to design and build a prototype laser altimeter instrument that would meet many of the topographic data requirements recommended for a Discovery



Mission Flyby/Orbiter. Analysis of existing lunar laser altimetry (Apollo system) and lunar topography will result in improved laser system specifications. The laser altimeter will be designed to minimize weight, power, and data rate, while maintaining reliable, continuous (long-lifetime) operations. The focus will be on an entirely solid-state laser transmitter involving diode-array pumping. Fast (1 - 3 nsec) Si Avalanche Photodiode (APD) detectors and waveform digitizers will be integrated with the diode-pumped redundant Nd:YAG lasers in a simple design. An Al telescope mirror will form the heart of the receiver. A single channel spectrometer mode (at 1.06 micrometers) will be explored. Techniques for obtaining profiles with two spatial resolutions (30 and 300m) will be studied. Link calculations will assess how easily the laser altimeter design could be enhanced for operations in asteroid orbit. This is a continuation of an RTOP which terminated in FY-91; we propose to continue the development of a Lunar Observer Laser Altimeter (LOLA) to be ready if Lunar Geoscience Orbiter (LGO) is given a new start and to develop a final Phase A report in FY-93.

**W93-70173****157-03-90**

Goddard Space Flight Center, Greenbelt, MD.

**MARS LIDAR (LIDAR FROM THE MARS SURFACE AND MARS ORBIT FOR ATMOSPHERIC STUDIES)**

James B. Abshire 301-286-2611

This RTOP will initiate work proposed under the Planetary Instrument Definition and Development Program (NRA 92-OSSA-06). We will investigate the design and performance of two different lidar systems to study Mars atmospheric processes. A compact lidar is being proposed for the Mars Environmental Survey (MESUR) program. This is a small system designed to view the zenith from the Mars surface and measure atmospheric backscatter profiles at 810 nm, and to measure high resolution atmospheric profiles at one location on Mars. We are also proposing a companion lidar for the Mars Aeronomy Observer. This lidar will use a 0.5 m diameter telescope, and will be designed to provide moderate resolution lidar profiles over the entire Mars surface covered by the spacecraft's orbit. Backscatter profiles measured with both instruments are essential to improving understanding of the height distributions and dynamics of dust and ground-fogs in the Mars atmosphere. Both lidars utilize similar technologies in lasers with high efficiencies and long lifetimes, small Si Avalanche Photodiode (APD) detectors and low power lidar electronics. In FY-93 we will (1) prepare theoretical models of both lidar systems, (2) select the optimum laser, (3) select lightweight telescope designs, (4) design, build and test breadboard of the MESUR Lidar, (5) test the performance of both instruments, and (6) investigate tradeoffs.

**W93-70174****157-04-80**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MICRO WEATHER STATIONS FOR MARS**

D. Crisp 818-354-2224

The lowest layers of the Martian atmosphere (0 to 4 km) are called the Planetary Boundary Layer (PBL). A complete understanding of the weather at these levels is essential for future robotic and manned missions to Mars because this will be the working environment. Our first opportunity to study the Martian PBL on a global scale will be provided by the Mars Environmental Survey (MESUR) Mission. That program will deploy a network of small stations on the Martian surface. An earlier opportunity to deploy a single small weather station might be offered by the 1996 MESUR Precursor Mission that is currently being considered. Existing instruments for studying meteorological processes are not well suited for this application because they are too massive, too fragile, or require too much power for deployment on the small platforms that are currently being considered for MESUR. We have therefore started to assess the feasibility and utility of miniaturized sensors for making meteorological measurements in the Martian PBL. The state-of-the-art silicon micro machining and semiconductor large scale integration technologies that are available in the JPL Micro Devices Laboratory (MDL) are being used to build and test sensors for measuring pressure, temperature,

wind velocity, humidity, and aerosol abundance. These sensors could be incorporated into complete weather stations that are rugged, compact, light-weight, and require very little power. They would therefore be ideal for the MESUR Mission and other future robotic and manned missions to Mars.

**W93-70175****157-05-50**

Goddard Space Flight Center, Greenbelt, MD.

**PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/PLANETARY ASTRONOMY HIGH TEMPERATURE SUPERCONDUCTOR BOLOMETERS**

J. Brasunas 301-286-3488

This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. Task 06 will develop higher sensitivity far-infrared detectors compatible with passive radiative coolers on long-term missions (greater than 5 years). Specifically, this task will develop high-temperature superconductor (HTS) bolometers for outer planet missions such as the 1996 Cassini mission to Saturn and Titan, for future planetary missions such as Uranus Orbiter, Neptune Orbiter, Pluto Flyby, Lunar and Mars missions, long-term Earth orbiting missions such as EOS and the Orbiting Planetary Telescope, and small/inexpensive missions such as the Small Explorer series.

**Solar Terrestrial SR&T****W93-70176****170-10-10**

Goddard Space Flight Center, Greenbelt, MD.

**COSMIC AND HELIOSPHERIC PHYSICS**

J. F. Ormes 301-286-8801

This RTOP is to support efforts within the Space Sciences Directorate at the Goddard Space Flight Center aimed at understanding the acceleration, interactions, and transport of energetic particles in astrophysical plasmas. The approach is remote and in-situ observations of energetic particles of galactic and solar origin in order to understand the propagation of energetic particles in the chaotic galactic and solar system magnetic fields, and to study the properties of the space plasmas in which their acceleration takes place. The particles observed are the nuclear and electronic species, their energy spectra, their charge states and isotopic composition, and their distribution in space. Planning of new missions is an important component of this research as analysis leads to increased understanding but more sophisticated questions. There is also a large effort directed at processing, analyzing, and interpreting the data involving correlative studies from a variety of spaceflight experiments such as Voyager, Pioneer, International Sun Earth Explorer (ISEE), Interplanetary Monitoring Platform (IMP), and Helios and comparisons with data from other observatories, both space and ground based. A strong emphasis is placed on creating the theoretical framework for interpreting the results. This RTOP supports graduate students' thesis research, research associates, and occasionally a senior faculty member on leave from an academic institution.

**W93-70177****170-10-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**COSMIC AND HELIOSPHERIC PHYSICS**

R. Goldstein 818-354-0241

This RTOP consists of 6 subtasks: (1) Solar Gamma-Ray Spectroscopy (170-10-10-67, J. Ling, W. Wheaton): Demonstrate critical technology for a solar high resolution gamma ray spectrometer; (2) Solar Wind Data Analysis (170-10-10-88, M. Neugebauer): Investigations of heliospheric physics, including acceleration of the solar wind and properties of discontinuities, using solar wind data acquired by past missions; (3) Magnetospheric and Interplanetary Data Analysis (170-10-10-89, E.J. Smith):

Analysis and interpretation of Pioneer and International Sun-Earth Explorer (ISEE) vector helium magnetometer and other data; (4) Radio Analysis of Interplanetary Scintillations (170-10-10-91, R. Woo): Probing of solar wind regions inaccessible to spacecraft using the scattering and scintillation of the spacecraft radio signals; (5) Model Analysis of Heliospheric Structure (170-10-10-94, J. Ajello): Analysis of solar and interplanetary UV from interplanetary spacecraft (P.V. Voyager, Galileo); and (6) Particle Simulations of the Solar Wind Termination Shock and Alfvén Wave Decay Instabilities (170-10-10-96, P. Liewer): Particle simulation codes are used to study Alfvén wave instability in the solar wind, and the effect of interstellar pickup ions on the solar wind.

**W93-70178****170-10-10**

Ames Research Center, Moffett Field, CA.

**MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION**

A. Barnes 415-604-5506

The objective of this RTOP is to improve the understanding of the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. The approaches of this RTOP are to conduct theoretical studies aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and waves and turbulence in the solar wind. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments will be related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind. Theoretical studies of the solar wind-Venus interaction will be conducted.

**W93-70179****170-38-52**

Goddard Space Flight Center, Greenbelt, MD.

**GROUND-BASED SUPPORT OF SOLAR PHYSICS**

Brian R. Dennis 301-286-7983

The major objectives of this program are listed. The first is to obtain and analyze observations of solar velocity and magnetic fields, oscillations, coronal holes, active regions, and flares at wavelengths observable from the ground. These observations complement UV, EUV, x ray, and gamma ray observations made from NASA spacecraft, sounding rockets, and balloons. The second is to support operational planning for flight-mission experiments and to measure solar inputs for predicting space environment parameters needed for orbital flight dynamics and manned mission activities. The last is to conduct basic research and develop specific instrumentation and observational programs relevant to objectives for future flight missions. The National Solar Observatory's (NSO) Vacuum Telescope at Kitt Peak (KPVT), Arizona is supported by the Laboratory through its Southwest Solar Station. High resolution, full disk magnetograms, and He I 10830 Å spectroheliograms are routinely obtained and substantial observing time is dedicated for spacecraft support and basic research by Laboratory staff. Solar oscillations are observed at the KPVT and during campaigns in the Antarctic to study oscillations throughout the solar cycle. Collaborative instrumentation and research programs are initiated and maintained with the National Solar Observatory and other colleagues.

**W93-70180****170-38-53**

Goddard Space Flight Center, Greenbelt, MD.

**THEORY, LABORATORY AND DATA ANALYSIS FOR SOLAR PHYSICS**

Gordon D. Holman 301-286-4636

The primary objective of this RTOP is to support the laboratory's on-going programs by developing techniques for the interpretation of solar data. The primary goal is to correctly interpret the nature of observable solar phenomena by understanding the fundamental physical processes. This involves obtaining an understanding of the conversion of mechanical energy associated with photospheric velocity fields into a nonthermal energy flux, the propagation of this nonthermal energy from its point of generation to the chromosphere and corona, and the release of

this energy in the chromosphere and corona. The focus is on the following areas: (1) the calculation of atomic transition probabilities and studies of nuclear and atomic collision processes in solar plasmas; (2) the development of techniques for determining the strength and structure of the solar magnetic field, from subphotospheric to coronal; (3) determining the physical processes responsible for the conversion of mechanical energy to coronal heating and the driving of the solar wind; (4) determining the physical processes responsible for heating, particle acceleration, and transport in solar flares; and (5) the consolidation of the above processes (1 to 4) into models that predict new solar phenomena and explain those already observed. The work utilizes and impacts observations of the sun across the entire electromagnetic spectrum, from radio frequencies to gamma rays.

**W93-70181****170-38-53**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SOLAR PHYSICS STUDIES**

R. Goldstein 818-354-0241

This RTOP consists of two tasks. The first task is the measurement of absolute electron-ion collision parameters in solar plasma diagnostics (number 170-38-53-55, A. Chutjian), specifically the measurement of electron-ion excitation collision strengths needed to interpret solar plasma properties such as electron density and temperature and ion formation temperatures (freezing in temperature). Use is made of the electron-energy loss method pioneered at the Jet Propulsion Laboratory (JPL), using merged electron and ion beams, trochoidal energy analysis, and spatial detection of electrons using a microchannel plate. The second task concerns the variability of solar UV irradiance and its relation to the evolution of active regions and coronal activity (number 170-38-53-26, J. Pap). A study is made of the relationship between the UV irradiance variability (from the Solar Mesosphere Explorer (SME) and other spacecraft measurements) and evolution of active regions using photospheric, chromospheric, and coronal indices of solar activity.

**Advanced Programs****W93-70182****186-06-01**

Ames Research Center, Moffett Field, CA.

**TELEPRESENCE FOR PLANETARY EXPLORATION**

G. Briggs 415-604-0218

(152-13-60; 199-52-82)

The objective of this RTOP is to develop and demonstrate the advanced capability to operate remote mobile robots to serve field scientific exploration purposes, eventually on the surface of the Moon and Mars. This includes both telepresence and virtual environment capabilities. The approach is to build a prototype telepresence system integrated into an available mobile platform, a submersible remotely operated vehicle (ROV) that is used for the exploration of ice-covered lakes in the dry valleys of Antarctica (a terrestrial Mars analog). The system will emphasize telepresence vision and will evolve to include telepresence manipulation. It will begin with lakeside operations and evolve to comsat operations from NASA-Ames. Initially, the system will include only telepresence and will evolve to include a virtual environment capability. The latter will be used to simplify navigation functions, to provide different view perspectives, to allow simultaneous field analysis participation, and to compensate for communications link time delays.

## Solar Terrestrial and Astrophysics SR&T

**W93-70183**

**188-41-21**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **DEEP OPTICAL/UV IMAGING OF QUASARS BELOW THE LYMAN LIMIT**

D. Hamilton 818-354-9617

Until recently the relationship between absorption lines systems found in high resolution spectroscopic studies of quasars and galaxies found in deep optical surveys have been dubious at best. We recently started a program aimed at using these complementary data sets to help provide a direct connection between galaxies found by quasar absorption line studies on the one hand and ultra-deep imaging surveys of the fields of quasars having intervening optically thick Lyman limit absorption systems which completely remove the bright quasar from the U-band on the other. The quasars observed and to be observed also have available high resolution spectroscopy, so that one has a priori knowledge of the redshifts of high redshift galaxies situated near the quasar sightline. Thus, one may image the very faint high  $z$  galaxies without contamination by the bright quasar in whose spectrum the redshift information has already been recorded. Using this method, which includes comparably deep images in two redder bandpasses, one may hope to assign redshifts to normal galaxies which are far too faint for conventional spectroscopy. This program is the first step and it is expected that we will extend the survey to quasars at lower redshifts using the WFPC-2 on the HST. The data obtained in the ground-based optical studies will aid in the planning of the WFPC-2 observations as well as contributing complementary information. We are requesting funds in order to be able to devote a fraction of time to the reduction and analysis of data already obtained and to obtaining additional data from further observing runs.

**W93-70184**

**188-41-21**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **OPTICAL STELLAR INTERFEROMETRY**

M. Shao 818-354-7834

The objective of this task is the development of advanced observational techniques for application to future space and lunar optical stellar interferometers, including the Orbiting Stellar Interferometer (OSI), proposed as a moderate mission for the end of this decade. The design of this instrument draws strongly on the ground-based Mark III optical interferometer, an operational Michelson stellar interferometer at Mt. Wilson, and the only instrument of its kind in the U.S. This includes not only the instrument design (configuration, aperture, etc.), but also the mission design: observing strategy, sequencing, data reduction, etc. Thus, the approach is to continue observations and data analysis with the Mark III interferometer in order to develop improved observational methods and data reduction techniques. The scientific productivity of the Mark III has improved enormously with increased observational experience; it is important to continue these observations so that those lessons can be applied to the space missions, where the learning process is much more expensive, in order to maximize their scientific productivity.

**W93-70185**

**188-41-22**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **RELATIVITY, COSMOLOGY, AND GRAVITATIONAL RADIATION**

H. D. Wahlquist 818-354-2538

The objectives of these tasks are to measure a variety of relativistic effects using space technology, especially precision Doppler tracking of spacecraft, planetary radar ranging, and lunar laser ranging. The investigations include both theoretical and observational research directed towards studying the relativistic dynamics of the solar system and the detection of low frequency gravitational waves. In addition, space based experiments in relativistic gravitation are studied to evaluate their feasibility and to define their technological requirements. In FY-93, the relativity

program will (1) continue studies of the continuous gravitational wave background using millisecond pulsar data and also of interferometer technology for gravitational wave detection in space; (2) develop signal processing methods for low frequency gravitational wave detection, focusing on signals expected from coalescing binaries; (3) continue theoretical research on cosmological sources of low frequency gravitational waves; (4) support observational tests of relativistic gravity theory, including geodetic precession, measurement of PPN parameters along with the Sun's J2, and a possible time variation in the Newtonian 'constant' of gravity, using planetary radar ranging and lunar laser ranging; (5) conduct a triple-coincidence gravitational wave search experiment with simultaneous Doppler tracking of Mars Observer, Galileo, and Ulysses; and (6) study relativity experiments that could be performed on a Solar Probe mission.

**W93-70186**

**188-41-23**

Goddard Space Flight Center, Greenbelt, MD.

### **OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY**

George Sonneborn 301-286-3665

Space based instrument systems for astronomy offer scientists many important advantages. In space, optical systems escape detrimental atmospheric effects such as absorption and turbulence, allowing observations in previously inaccessible spectral ranges and the potential to measure ultra-faint and ultra-small objects. However, the technologies for space optics are fundamentally different than those for ground based systems. Technology developments for space optics specifically must address the expanded spectral region (x rays to far-IR), the vacuum environment, zero gravity, contamination, radiation damage, and the severe weight and volume constraints placed on payloads. The objective of this research and technology program, therefore, is to conduct investigations in those technology areas generic to the development of astronomy instrumentation for space. Relevant technical areas include optical system design and analysis, optical materials, optical fabrication, optical testing, mirror technology, and diffraction grating technology. Investigations are presently being conducted in two technical areas that will have substantive cost/performance payoffs. In optical materials research, major emphasis is placed on ultraviolet mirror coating developments to improve system throughput. In the area of diffraction grating technology, studies of advanced design, fabrication, and testing methods are being conducted.

**W93-70187**

**188-41-24**

Goddard Space Flight Center, Greenbelt, MD.

### **DEVELOPMENT OF UV PHOTON COUNTING GEOMETRICALLY STABLE ARRAY DETECTOR - MULTI-ANODE MICROCHANNEL ARRAY (MAMA)**

Bruce E. Woodgate 301-286-5401

The objectives of this task are to continue development of the Multi-Anode Microchannelplate Array (MAMA) detector beyond the capabilities being used for the Solar and Heliospheric Observatory (SOHO) and the Space Telescope Imaging Spectrograph (STIS), particularly in the area of spatial resolution and dynamic range. The method of developing geometrically stable array detectors is to use a two-dimensional coded wire array behind a microchannelplate (MCP) electron intensifier. A photocathode on or near the front of the MCP converts a photon to an electron image. The MCP has sufficient gain to allow counting of individual photoelectrons. Investigations will include the use of smaller pores in the MCP's, subpixel decoding, and low resistance MCP's.

**W93-70188**

**188-41-24**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **BAND STRUCTURE ENGINEERING ON SILICON CCDS FOR ENHANCED UV RESPONSE**

P. Grunthaner 818-354-0360

The objective of this task is to demonstrate stable, broad band silicon charge coupled device (CCD) imagers with quantum efficiency at ultraviolet wavelengths (100 to 350 nm) limited only by the reflectivity of the silicon surface. The approach is to use the atomic layer control of molecular beam epitaxy (MBE) to grow

a highly doped p(+) epitaxial layer of silicon on the backside of a commercial EG&G Reticon CCD array prior to final bonding and packaging. Because the p-type charge is incorporated directly into the crystal structure of the CCD silicon substrate, this approach is inherently stable against all environmental effects. Theoretical modeling has shown that this epitaxial layer will completely eliminate the backside potential well that traps the carriers generated by ultraviolet radiation. After demonstrating the MBE-modified CCD, this task will also deposit anti-reflection layers on the modified backside to further enhance the ultraviolet (UV) response.

**W93-70189****188-41-51**

Goddard Space Flight Center, Greenbelt, MD.

**UV ASTRONOMY AND DATA SYSTEMS**

A. V. Sweigart 301-286-6274

The objectives are to perform theoretical and observational astronomical research of particular importance for space observations; to develop and use new instrumentation for imaging and spectroscopy of astronomical objects; to utilize image processing programs on Goddard computers; to develop tools and techniques which will facilitate and improve the reduction, analysis and understanding of astronomical data; to support an optical telescope observatory for testing research ideas for space projects; and to develop new instrumentation for observing astronomical objects. The approach is (1) to obtain detailed stellar evolutionary models for interpreting space observations, particularly those to be made with the Hubble Space Telescope and the Ultraviolet Imaging Telescope; (2) to perform appropriate ground and space observations to study stars, nebulae, the interstellar medium and extragalactic objects; (3) to perform theoretical studies in support of space observations; (4) to develop and use new instrumentation for imaging and spectroscopy of astronomical objects; (5) to develop and utilize image processing programs on Goddard computers; (6) to obtain ground-based observations in support of space observations; and (7) to develop suitable instrumentation for and maintain the NASA/GSFC 36 inch telescope.

**W93-70190****188-41-57**

Goddard Space Flight Center, Greenbelt, MD.

**PHOTOPROCESSES/SPECTROSCOPIES OF ASTROPHYSICAL MOLECULES AND RADICALS**J. E. Allen, Jr. 301-286-5896  
(154-50-80; 154-75-80)

The principle objective of this laboratory program is to provide experimental data on photoprocesses and spectroscopies of radicals and molecules, the measurement of which can lead to a better understanding of astronomical objects and astrophysical systems. The information obtained can be used to model observations, develop interpretive/predictive models of astrophysical systems and guide the calculation of physical parameters that might otherwise be difficult to measure. In some instances the acquisition of these data requires the development or implementation of emerging experimental techniques. Under this RTOP physical and spectroscopic quantities such as vertical excitation energies, photodissociation and photoionization cross sections, neutral/ion product yields and oscillator strengths are measured for radicals and molecules that are particularly important in the interpretation of astronomical observations at visible and ultraviolet wavelengths. Each activity in this program presents its own set of experimental difficulties which are being addressed by a variety of techniques. Unlike stable molecules, radicals are chemically reactive which precludes the use of standard techniques and makes it difficult to acquire relevant data. To circumvent these problems, laser-depletion spectroscopy is being used to acquire vertical excitation energies for dissociative potential energy surfaces of diatomic radicals. This information is critical to the calculation of photodissociation cross sections as a function of wavelength. In related experiments photolysis cross sections for radicals are measured at single wavelengths using a fast-flow reaction system combined with an excimer laser and detection of the photoproduct by resonance fluorescence. For stable molecules, particularly triatomics, the competition between photodissociation and

photoionization is examined by following the photoemission of the radical product versus the photoion yield as a function of wavelength. For larger species, such as polycyclic aromatic hydrocarbons (PAH's), electron energy loss spectroscopy is employed to obtain relative and absolute oscillator strengths from the near infrared to the far ultraviolet and x-ray regions of the spectrum.

**W93-70191****188-41-57**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**OPTICAL/UV LABORATORY ASTROPHYSICS**

J. M. Ajello 818-354-2457

Laboratory Astrophysics studies of electron impact cross sections and oscillator strengths of cosmically abundant atoms, molecules and their ions are conducted at the Jet Propulsion Laboratory (JPL). The resulting data are available for analysis of Hubble Space Telescope, Extreme Ultraviolet Explorer (EUVE), Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS), ASTRO-2, and Far Ultraviolet Spectroscopic Explorer (FUSE) observations of visible, ultraviolet (UV), and x-ray spectra. The laboratory data will be generated by performing experiments using (1) electron impact excitation to measure UV fluorescence spectra at high spectral resolution; (2) energy loss spectra of neutrals and ions at high electron energy resolution; and (3) lifetimes at high time resolution. The principle application of these atomic and molecular parameters are to model observations of diffuse molecular clouds, the interstellar medium, and stellar atmospheres.

**W93-70192****188-44-01**

Goddard Space Flight Center, Greenbelt, MD.

**RESEARCH COMPUTING FACILITY AND CATALOGING FOR INFRARED**

N. W. Boggess 301-286-6989

The scientific objectives of this program are to enhance the ability to interpret observations and continue updating catalogs of infrared observations for the benefit of the astronomical community. This program will maximize scientists' abilities to interpret observations and provide information for efficient observing programs. Tools and techniques which will facilitate and improve data reduction, analysis, and understanding of astrophysical data are being developed. The cataloging effort is made available to the scientific community at large, and the computing facilities are made available to visiting scientists.

**W93-70193****188-44-21**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**INFRARED/RADIO RESEARCH**P. Wannier 818-354-3347  
(188-44-23)

The objectives of this research are to carry out radio and infrared observations and analysis relating to galactic and extragalactic astronomy. The facilities used include NASA's deep space network, and the research relates to such future space missions as the Space Infrared Telescope Facility (SIRTF), a submillimeter mission (SMMM), and orbiting very long base interferometry (VLBI).

**W93-70194****188-44-23**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SUBMILLIMETER ASTRONOMY**T. B. H. Kuiper 818-354-5623  
(188-44-21)

The objectives of this activity are to study the interstellar medium using very high spectral resolution astronomical observations of molecular and atomic transitions. The observations will probe the physical conditions in molecular clouds, star forming regions, and circumstellar envelopes of late-type stars. Millimeter and submillimeter wave spectral lines provide diagnostics of cold molecular clouds, and of very dense, warm molecular gas as it interacts with stellar objects: protostars, T-Tauri stars, and late-type stars. Measurements of interstellar molecules at frequencies where the terrestrial atmosphere hinders observation are essential to

understand the evolution of molecular clouds and star formation. Besides the intrinsic difficulty of making such observations, this part of the spectrum has been largely unexplored because the required technologies are still in their infancy. This activity places strong emphasis on the development and use of state-of-the-art superconductor insulator superconductor (SIS) heterodyne receivers. One task addresses the determination of the abundance of interstellar H<sub>2</sub>O-18, and by implication, H<sub>2</sub>O. Airborne observations of dense molecular cloud cores are planned for 1994. The other task addresses the determination of the abundance of interstellar O<sub>2</sub>. Balloon observations will be made of a variety of molecular clouds and star forming regions in order to determine how the abundance of O<sub>2</sub> varies as clouds evolve. These activities lend strong support to future spaceborne submillimeter wavelength astronomical missions based on high spectral resolution (heterodyne) spectroscopy. This research focuses on observations from very high mountain tops (e.g., Mauna Kea at 4.1 km) during exceptional conditions, from the NASA airborne observatory (up to 12.5 km), and from balloons (up to 42 km). A 547 GHz receiver is being constructed for use on the Kuiper Airborne Observatory in 1994. A receiver system operating at 119 GHz will be flown with the UCSB balloon-borne 1 m telescope. The receiver will have a single sideband system temperature of 100 K. The angular resolution will be 12 feet. An engineering flight is planned for June 1992.

**W93-70195****188-44-23**

Ames Research Center, Moffett Field, CA.

#### **INFRARED AND RADIO ASTROPHYSICS TECHNICAL DEVELOPMENT: GROUND-BASED ASTRONOMICAL INSTRUMENT**

T. L. Roellig 415-604-6426

The objective of this RTOP is to develop advanced technology for use in infrared and radio astronomical instrumentation. The technology being developed under the tasks at the NASA Ames Research Center (ARC) will be utilized at ground-based observatories in a wide variety of astrophysical studies, including imaging of planetary, galactic, and extragalactic objects. As part of this program, two instruments will be constructed, one a photometer cooled by adiabatic demagnetization refrigeration that will be used at submillimeter wavelengths (ADRPH) and the other a large format infrared camera capable of being used in the 10 and 20 micron atmospheric windows (AIRC). The approach of this RTOP is to build on existing technology and facilities here at NASA-ARC, extending the technology beyond the developmental stage to allow it to be employed in useable, state-of-the-art, astronomical instrumentation.

**W93-70196****188-44-23**

Goddard Space Flight Center, Greenbelt, MD.

#### **INFRARED, SUBMILLIMETER, AND RADIO ASTRONOMY**

N. W. Boggess 301-286-6989

The scientific objective of this program is to provide a better understanding of the current state and evolution of the universe as a whole and of specific objects within it. This is achieved by making, analyzing, and interpreting observations at wavelengths from 1 micron to 1 mm and at a wide range of spectral resolving powers. Since atmospheric opacity and emissivity prohibit it or severely limit ground-based observations at certain wavelengths, high altitude platforms such as the Kuiper Airborne Observatory, balloons, or satellites must be used. High sensitivity composite bolometers are being developed in the far infrared to take maximum advantage of low background conditions at those altitudes. A balloon-borne 1.5 m telescope is used to measure the small scale anisotropy of the cosmic background radiation; an infrared camera is used to image efficiently galactic and extragalactic sources.

**W93-70197****188-44-24**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### **DEVELOPMENT OF 1036 GHZ RECEIVER FOR ASTRONOMY AND NEAR IR IMAGING AT PALOMAR**

M. A. Frerking 818-354-4902

This RTOP covers two tasks: development of technology for

1000 GHz heterodyne capability and the development of a near IR imaging camera for use at the Palomar Observatory. The original objective of the first task was to demonstrate in the laboratory a heterodyne receiver operating above 1000 GHz using components baselined for SMIM superconductor-insulator-superconductor (SIS) tunnel junction mixers. Due to lack of funds, that objective was descope to address key technical issues associated with high frequency SIS heterodyne mixer operation. In particular, superconducting integrated tuning elements to better couple radiation into the mixers are being studied. In addition, parameters of the superconducting distributed circuit elements, such as loss and phase velocity, are being characterized for frequencies greater than 500 GHz. A parallel task to develop a solid-state local oscillator source that was part of the original proposal is being carried out independently at the University of Massachusetts. Two papers have been accepted for publication during the last year based on this effort. The second task provides partial support for a number of observational programs at Palomar in infrared astrophysics: the formation of solar-type stars, the luminosity function of high mass stars in giant molecular clouds, the energetics of Infrared Astronomical Satellite (IRAS) bright galaxies, a search for counterparts to Lyman alpha absorbing systems seen toward distant quasars, and the search for ultra-luminous infrared objects at high redshifts. These programs are being carried out with an infrared camera at the prime focus of the Palomar 5-m telescope. Last year we upgraded the camera by replacing its Rockwell-HIRES 256 x 256 array with a lower noise NICMOS II 128 x 128 array. We have had three successful runs using this array. We are now upgrading the camera again to incorporate a Near Infrared Camera and Multi-Object Spectrometer III (NICMOS III) 256 x 256 array purchased with support from this grant as well as from internal JPL funding. Support is requested to assist with laboratory testing of the new array, and for new optical elements to improve the quality of the images over the larger field enabled by the new 256 x 256 array. Three papers have been accepted for publication during the last year based on this effort.

**W93-70198****188-44-53**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### **SIMULATIONS OF COMPACT RADIO SOURCES**

D. L. Meier 818-354-5062

The purpose of this research is to support the NASA space-based and ground-based observations in the radio region of the spectrum with theoretical work to improve the understanding of hydrodynamical and magnetohydrodynamical processes in radio sources. In FY-93, these programs will use our magnetohydrodynamic (MHD) jet and accretion disk simulation code, recently ported to the new Caltech Intel Touchstone DELTA parallel supercomputer, to perform an intensive study of magnetic accretion disks and their potential for producing, collimating, and accelerating jets, with special emphasis on extremely CPU- and data-intensive calculations on the DELTA. We are also embarking on the creation of an entirely new field of numerical astrophysics which will attack implicit, multi-dimensional problems, such as thick accretion disks and rotating stars, using the Finite Element Method. This latter method has been used extensively in the field of structural engineering to solve similar problems.

**W93-70199****188-44-53**

Ames Research Center, Moffett Field, CA.

#### **THEORETICAL STUDIES OF GALAXIES, THE INTERSTELLAR MEDIUM, MOLECULAR CLOUDS, STAR FORMATION**

B. F. Smith 415-604-5515

The objective of this research is to better understand (1) the formation and evolution of galaxies and clusters of galaxies; (2) basic processes which determine the state and infrared radiative properties of the interstellar medium in galaxies; (3) molecular clouds and star formation; and (4) the structure and evolution of the atmospheres of evolved stars. This research is being stimulated by observational advances and expected capabilities of new NASA observational programs. The approach of this effort involves theoretical analyses and computational astrophysics employing a wide variety of numerical codes developed at Ames to treat

fundamental problems in the areas of interest. These numerical codes treat multi-dimensional hydrodynamic and magneto-hydrodynamic fluid problems, multi-dimensional particle problems, and complex chemistry and radiative transfer situations. This effort makes effective use of the advanced computational facilities at Ames.

**W93-70200****188-44-53**

Goddard Space Flight Center, Greenbelt, MD.

**THEORY AND MODELING: INFRARED, SUBMILLIMETER, AND RADIO**

N. W. Boggess 301-286-6989

The scientific objectives of this program are to provide a better understanding of the current state and evolution of the universe as a whole and of specific objects within it. This is achieved by conducting theoretical and analytical studies, including sophisticated modeling, in which the emphasis is on examining effects in the wavelength range 1 micron to centimeters. Tools and techniques which will facilitate and improve theoretical analysis and enable maximum insight into the understanding of astrophysical data are being developed.

**W93-70201****188-44-57**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**LABORATORY ASTROPHYSICS**

H. M. Pickett 818-354-6861

The objective of this work is to make measurements and provide laboratory data in support of NASA's missions in astrophysics, particularly those missions using molecular signatures in the infrared, far infrared, submillimeter and microwave regions of the spectrum. In one thrust of this research, primary spectral data is obtained in the laboratory, and theoretical models based on this and other data are cataloged and made available to the general astrophysics community. These cataloged results are then used for both planning and interpreting observations with either airborne or spaceborne instrumentation. A second thrust of this laboratory astrophysics work involves measurement of ion-molecule reactions and their interpretation. Radiation association reactions are a class of ion-molecule reactions important in the evolution of interstellar gas clouds. The aim is to study these reactions in the laboratory and develop methods of predicting the importance of similar reactions that are not measurable in the laboratory. A third thrust of this work involves the study of infrared emission from polyaromatic hydrocarbons (PAH's). The focus is on optimizing laser desorption sources for PAH's with detection of ionized PAH spectra.

**W93-70202****188-44-57**

Ames Research Center, Moffett Field, CA.

**PROPERTIES OF INTERSTELLAR PAH'S**

L. J. Allamandola 415-604-6890

The objective of this RTOP is to understand why free, molecular sized, polycyclic aromatic hydrocarbons (PAH's) are surprisingly abundant in many different astronomical objects. They are a widespread, previously unrecognized component of the interstellar medium and play a dramatic role in determining many properties of interstellar clouds, such as energy balance, molecular cloud temperature and chemistry, and carbon dust particle formation. The approach of this RTOP is to increase knowledge of the spectroscopic, physical and chemical properties of PAH's in the forms in which they are likely to exist in space: ions, radicals, neutral species, and clusters. Spectroscopic properties of these unique species are particularly important to know since all telescopic data pertaining to this problem are spectroscopic. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further the understanding of the roles of PAH's in astrophysics. Experiments are underway in the laboratory in which PAH's are prepared under conditions which duplicate, as much as possible, the interstellar conditions in which they are found.

**W93-70203****188-44-57**

Goddard Space Flight Center, Greenbelt, MD.

**LABORATORY ASTROPHYSICS**

J. Nuth 301-286-9467

(152-12-40)

The overall objective of this program is to obtain laboratory measurements of quantities and processes which can lead to a better understanding of astrophysical systems. As part of this general objective, both theoretical analyses and studies to model appropriate systems are undertaken. The objectives of the specific tasks supported under this RTOP are: (1) to obtain high resolution spectra (one part in  $10^{(exp 7)}$ ) of isotopically labeled molecules in sufficient detail to construct energy level diagrams of individual vibrational states; (2) to determine the pre-condensation cluster distribution leading to the nucleation of refractory circumstellar particles; (3) to determine the spectra of amorphous grains of various compositions for comparison with interstellar/circumstellar dust; (4) to obtain far-infrared spectra of various ices and grains for comparison with astrophysical observations using SIATF and SOFIA; and (5) to understand photodissociation processes for molecules and radicals in circumstellar and interstellar environments. Data required to achieve the above objectives will be obtained using a variety of experimental techniques and equipment. In particular, objective (1) will be accomplished using a combination of tunable diode lasers and Fourier Transform Spectrometers (FTS). Objective (2) will be accomplished using a unique dust generator built at GSFC and a combination of annealing/hydration systems, a UV-visible spectrometer and an FTIR spectrometer. Objective (4) requires use of a low-T cryostat, FTIR, and a 1 MeV proton accelerator. Objective (5) requires the use of UV light sources and tunable dye lasers.

**W93-70204****188-46-01**

Ames Research Center, Moffett Field, CA.

**THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STAR OBJECTS (QSOS)**

F. C. Witteborn 415-604-5520

The objective of this RTOP is to understand the origin of the continuum spectra of compact, luminous objects such as active galactic nuclei. An optically thick, relativistic outflow is believed to arise in the core of these objects. The evolution of the distribution functions of the photons and pairs in this core is followed from an arbitrary start until a characteristic spectrum is reached or until the spectrum freezes out. The emergent electron-positron photon spectrum is compared directly with observations. The interaction of the emergent electron-positron pair wind or jet is modeled and its predicted radiation is compared with observations. The approach of this RTOP is to model interaction processes which are likely to be important to the spectrum: pair production, pair annihilation, Compton scattering and bremsstrahlung. In addition, synchrotron emission is important in a strongly magnetized plasma. The research will be extended by modelling the dynamics and spectrum of the pair jet which emerges from the optically thick core and can be observed directly in radio-string objects.

**W93-70205****188-46-01**

Goddard Space Flight Center, Greenbelt, MD.

**HIGH ENERGY ASTROPHYSICS: DATA ANALYSIS, INTERPRETATION AND THEORETICAL STUDIES**

J. F. Ormes 301-286-5705

This RTOP is to support laboratory efforts at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments, and to conduct theoretical studies to support this effort. These theoretical and interpretive studies lead to the publication of results in the scientific literature and help in the planning of new missions in the areas of x ray and gamma ray astronomy, energetic particles, and cosmological studies. Multisatellite data sets, such as those of Ariel 5, Orbiting Solar Observatory (OSO) 8, High Energy Astronomy Observatory (HEAO) 1 and HEAO 2 provide a basis of information which for many x ray sources remains complementary to the results of recent missions such as European X ray Observatory Satellite (EXOSAT) and Ginga, and upcoming missions such as Roentgen Satellite



(ROSAT) and Broad Band X-Ray Telescope (BBXRT). These data continue to provide important pieces of the still incomplete pictures of the unresolved physical systems that make up cosmic x ray sources, especially when they are compared with other data, either from other x ray observatories, or from space or ground based observations at other wavelengths. An additional important task is the definition of the manner in which new data will be added to this repository for future work by archival investigators. Strong emphasis is placed on creating the theoretical framework for interpreting the results, using the data to test recent theoretical work, and carrying out studies to test the feasibility of measurements with future missions. This RTOP supports graduate student thesis research, research associates, and an occasional senior faculty member on leave from an academic institution.

**W93-70206****188-46-57**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GAMMA-RAY ASTRONOMY AND TECHNOLOGY DEVELOPMENT**

W. A. Mahoney 818-354-6606

In order to avoid source confusion, to locate point sources well enough to allow identification with known objects, and to map the steep gradients expected toward the galactic center for diffuse sources, future high-resolution nuclear gamma ray spectroscopy experiments will require greatly improved imaging capabilities over those of past or future missions as presently defined. In addition, systems will be required which can reliably cool the germanium detectors to about 80 K for many years without introducing noise from microphonics. One of these research and analysis tasks involves the multi-year development of a laboratory instrument which will demonstrate fine imaging capabilities together with the superb energy resolution of conventional germanium detectors. The instrument will consist of a multi-detector cryostat containing advanced segmented germanium detectors, an appropriate coded aperture, and associated signal processing electronics. The second task involves balloon flight testing of a segmented germanium detector as well as performance evaluation of the segmented detector cooled by a Stirling cycle refrigerator to assure that there are no microphonics problems. During FY-92 extensive laboratory tests were conducted with a 5-segment germanium detector and a coded aperture, and two-dimensional image reconstruction was demonstrated. The performance of a 5-segment detector will be evaluated during a balloon flight in the spring of 1992. During FY-93, a second detector will be fabricated and work will begin on the laboratory multi-detector experiment. In FY-93, analysis will be completed on the balloon flight data and the performance of a segmented detector subjected to cooling with a mechanical refrigerator will be measured and evaluated. Segmented germanium detectors will almost certainly be used as the prime sensors in the next space-based gamma ray experiment beyond the Compton Gamma Ray Observatory, and cooling will undoubtedly be provided by mechanical refrigerators. All the technology developed under these tasks will be directly applicable to future gamma ray spectroscopy missions.

**W93-70207****188-46-57**

Goddard Space Flight Center, Greenbelt, MD.

**GAMMA RAY ASTRONOMY**

Carl E. Fichtel 301-286-6281

The technical objective is to develop the most appropriate detector systems for the observation of astrophysical sources of very energetic photons. The first approach was the development of a large high energy telescope using digitized spark chambers. Many major improvements to this basic telescope system have been pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low energy gamma-ray observations. In the high energy region, improvements in the track imaging chamber systems are continuing, and special attention in the track imaging chamber research is now being directed towards drift chambers. At the same time, several approaches are being explored to improve angular resolution, including techniques to concentrate on higher energy photons, and sensitivity, including the study of techniques to build

much larger systems. Improved approaches to the energy measurement and coincidence system also are being pursued. In the range from 0.5 to 40 MeV, it is apparent that substantial sensitivity improvement will require elimination of the ambiguity produced by conventional Compton telescopes in determining the direction of a detected gamma ray. New detector technology and a new approach is therefore required. For gamma-ray burst studies, new detector systems are being developed both for the gamma-ray energy range and for detection at other wavelengths. In particular, a ground-based system was developed to detect and precisely locate optical flashes that are likely to occur in coincidence with gamma-ray bursts. It was installed at Kitt Peak National Observatory and operation has begun.

**W93-70208****188-46-58**

Goddard Space Flight Center, Greenbelt, MD.

**GAMMA-RAY SPECTROSCOPY**

Bonnard J. Teegarden 301-286-5277

The objectives of this effort are to develop new instrumentation to perform high resolution spectroscopy and imaging of celestial gamma-rays in the 0.01 to 10 MeV range and to fly this instrumentation on high altitude balloons to assess the performance in a space-like environment and to gather scientifically meaningful data. In particular, the instrumentation will be designed to search for and measure the properties of narrow lines in the celestial gamma-ray spectrum. A major goal of this work will be the demonstration of new ideas and techniques for the eventual use in a satellite-borne experiment. The approach will center on the use of high purity Germanium detectors to perform the most precise possible measurements of the gamma-ray energy. In addition, new techniques will be explored to further suppress instrumental background and thereby improve the sensitivity of the experiment. Finally, new methods will be explored for constructing images of the gamma-ray sky with an accompanying improvement in angular resolution over earlier experiments.

**W93-70209****188-46-59**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**X-RAY ASTRONOMY CCD**

S. A. Collins 818-354-7393

The objective of this task is to develop, in a joint effort with Pennsylvania State University (PSU), a charge-coupled device (CCD) which is suitable for use as an astronomical detector of soft x-rays and to support the use of this detector in an instrument which will acquire energy-resolved x-ray images of astronomical sources from the NASA/CONAE satellite, SAC-B. This task will be accomplished by designing and fabricating CCD's which combine proven features to provide high sensitivity at photon energies of 0.3 to 2.0 KeV with very low noise (approx. 0.5 electrons, rms) signal readout.

**W93-70210****188-46-59**

Goddard Space Flight Center, Greenbelt, MD.

**HIGH THROUGHPUT X-RAY SPECTROSCOPY**

F. Marshall 301-286-5279

The Goddard Space Flight Center (GSFC) X-Ray Astronomy Group has repeatedly made major technological breakthroughs that have qualitatively improved capabilities for spectroscopy in the x-ray band. These advances, from proportional counters to x-ray calorimeters to broad-band x-ray optics, have all had their origins in our Space Research and Technology program. We intend a broad-based program to continue this development both by enhancing current technologies and by developing promising new technologies. We plan a systematic program to develop techniques to approach the intrinsic spatial resolution of conical foil x-ray optics, whose high filling factor and flat-field characteristics are powerful advantages for many investigations. We plan enhancements in x-ray calorimeters, including new technologies for thermometers and absorbers, which may improve their energy resolution by an order of magnitude. With a view farther into the future, we plan to develop Josephson junctions as x-ray detectors. There is the promise of detectors with the spatial resolution of charge coupled devices (CCD's) and the spectral resolution of

current calorimeters. A key to our progress in detector and mirror technology has always been and will continue to be the ready availability of the proper calibration facilities. Our current capabilities are becoming inadequate, and we are investigating appropriate upgrades. Finally, we plan the first astronomical observations using x-ray calorimeters in a series of rocket flights. The first flight will provide the first truly high resolution spectroscopic observation of the soft x-ray background. It will test in a fundamental way our understanding of the interstellar medium and, by constraining models for the extragalactic x-ray background, will contribute to our understanding of the evolution of active galaxies and quasars.

**W93-70211****188-78-01**

Goddard Space Flight Center, Greenbelt, MD.

**INTEGRAL MISSION DEFINITION STUDY**

Sam E. Bergeson-Willis 301-286-5344

The objective of this effort is to study mission issues relevant to flying a high resolution germanium detector on a European spacecraft for gamma-ray spectroscopy. The INTEGRAL Mission was accepted for final competition by ESA in FY-92 and the scope of this RTOP has, therefore, been reduced to exclude farther consideration of the Nuclear Astrophysics Explorer Mission. The specific goals for FY-93 are in two parts. First, from October 1992 to June 1993, the efforts involve working with the American and European gamma-ray science communities, ESA, and their contractors to develop and demonstrate the feasibility of all launch vehicle, spacecraft, instrument module, instrumentation, and science aspects of the INTEGRAL Mission and their associated costs. The object is to gain selection as the ESA M2 Mission in June over three competing missions. After selection in June, the objective will be to prepare to respond to an Announcement of Opportunity for the spectroscopy portion of the mission.

**W93-70212****188-78-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GRAVITY WAVE MISSION DEFINITION STUDY**

R. W. Hellings 818-354-3192

The purpose of this research is to investigate technology issues for missions to detect gravitational waves. Recent advisory panels have identified gravitational wave detection as the number-one goal of experimental gravitation in space. In the last year, we have identified a descoped version of a laser interferometer gravitational wave antenna that seems to require technology that can be developed in the near term (4 to 6 years). Several aspects of this mission need to be studied to refine technology requirements or to demonstrate where the technology is already available. These will be the particular goals for the current year.

**W93-70213****188-78-41**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**OPTICAL INTERFEROMETRY IN SPACE**

M. D. Rayman 818-354-2544

The primary objective of this RTOP is to define an astrometric interferometry mission responsive to the recommendations of the Astronomy and Astrophysics Survey Committee for launch early in the next decade. The targeted wide-angle astrometric accuracy is 3 to 30 microarcseconds on objects as faint as 20th magnitude. The concept is based on the Orbiting Stellar Interferometer (OSI) architecture. In FY-91, basic mission and flight system designs were formulated, science performance was predicted, and preliminary cost estimates were developed for a point design. In FY-92, the lessons learned in the first point design were used to develop a lower cost mission option. In addition, further definition was developed on the instrument and the flight subsystems. In FY-93, the mission option developed in FY-92 will be used as a basis for conducting trade studies with emphasis on continuing to reduce the cost and complexity. A preliminary operational scenario will be developed and used in these subsystem trades, as well as in modeling and requirements definition. Because of the very tight requirements on the optics and the optical paths through the spacecraft, thermal and structural models will be developed and used to estimate the performance in the presence of the predicted disturbance environment. These results will be used to improve

the confidence in the performance predictions, and they will be fed back into the instrument and flight system designs with the objective of continuing to develop a low-cost design with high quality science return. A key technology challenge for this mission is the development of relative metrology systems with subnanometer-level accuracy and absolute metrology systems with 20 micron accuracy. In FY-92, relative and absolute metrology testbeds were designed, developed, and tested. In FY-93, these testbeds will be used in an effort to demonstrate 1 nm accuracy for a one-dimensional relative metrology system and 50 micron accuracy for an absolute metrology system (the final required performance will be demonstrated in FY-94). In addition, the design for articulated laser beam launchers will be developed and construction of a working system will be initiated in the laboratory. The Space Interferometry Science Working Group (SISWG) will be supported in its process of deciding on the preferred candidate for the Astrometric Interferometry Mission, and directives from the SISWG will be incorporated into the technical work undertaken during the year.

**W93-70214****188-78-44**

Ames Research Center, Moffett Field, CA.

**IR ASTRONOMY ATD/CRYO OPTICAL TESTING AND SCIENCE SUPPORT ACTIVITIES**

C. R. McCreight 415-604-6549

The objective of this RTOP is the development of key optical technologies for future astronomical missions in general and the Space Infrared Telescope Facility (SIRTF) in particular. SIRTF is intended to operate under diffraction- and background-limited conditions at liquid helium temperatures. To insure that diffraction- and background-limited conditions exist, this RTOP investigates the problems of improving optical performance at cryogenic temperatures and the reduction of scattered light to a minimum.

**W93-70215****188-78-44**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ASTROTECH 21**

R. Capps 818-354-0720

The objective of Astrotech 21 is to assist NASA's Astrophysics Division in formulating and implementing a long range technology plan for future Astrophysics missions. The planning process includes the definition of science objectives and observational techniques, new mission concepts and their associated technology requirements; and integrated technology planning. The Astrotech 21 technology program will be implemented by the Astrophysics Division in cooperation with the Office of Aeronautics, Exploration and Technology (Code R). The work is now in transition with the initial planning phase now winding down and the implementation phase beginning. The planning activity has involved more than 1000 scientists and technologists who have participated in 11 workshops culminating in the Integrated Technology Workshops in Information Systems, Sensor Systems and Optical Systems. There has been information interchange with several subcommittees of the decadal Astronomy and Astrophysics Survey Committee (AASC), also known as the Bahcall committee, whose deliberation occurred concurrently with this first phase of the Astrotech 21. The proposed activity is within the Code SZ Guidelines and will complete the initial planning activity for Information Systems, Optical Systems and Sensor Systems. This activity will address the Integrated Technology Planning for Observatory Systems. This activity had been proposed for inclusion in the Astrotech 21 planning activity in FY-92 but was deferred because of budget considerations.

**W93-70216****188-78-60**

Ames Research Center, Moffett Field, CA.

**STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)**

G. W. Thorley 415-604-5917

The objectives are to define and initiate development of the Stratospheric Observatory for Infrared Astronomy (SOFIA), to define the ground support system and to develop the operational procedures for the airborne observatory. The SOFIA is a proposed



new observatory to continue NASA's airborne IR astronomy program as the successor to the Kuiper Airborne Observatory (KAO). The SOFIA features a 2.5-meter telescope mounted in a modified Boeing 747SP aircraft. Potential users of the SOFIA would make observations ranging from about 0.3 microns to 1.6 mm in wavelength. The SOFIA will provide a significant increase in scientific capability over the KAO. The approach is to: (1) continue development of the technology needed for the design and development of the SOFIA; (2) to coordinate the results of the previous studies and the technology development, and to increase the depth of the system definition and systems analysis by completing definition studies of the aircraft system, telescope system and ground support system; (3) to survey probable contractors and continue development of the aircraft system, the consoles and electronics system and the Federal Republic of Germany (FRG) telescope assembly; (4) to complete studies to assess moving the telescope cavity to the aft of the aircraft and develop a U.S. Telescope option; and (5) to study acquisition and refurbishment options for a used Boeing 747SP for the SOFIA platform. The work will be performed in-house at Ames Research Center, under contract to industry, and in collaboration with the FRG.

## Planetary Astronomy

### W93-70217

196-41-03

Lyndon B. Johnson Space Center, Houston, TX.

#### OBSERVATIONS OF THE MOON, MERCURY, AND PRIMITIVE ASTEROIDS

A. E. Potter 713-483-5061

This RTOP has two general objectives: (1) to understand the exospheres of Mercury and the Moon by study of the sodium and potassium atmospheres of these objects via high-resolution spectroscopy and imaging with ground-based telescopes (the observed abundance and spatial distribution of these atmospheres is interpreted through theoretical modeling and radiative transfer calculations); and (2) to study the composition of primitive (C, P, D, F) asteroids through the study of their spectral properties, and to apply the acquired knowledge to the understanding of the formation conditions throughout the outer part of the main asteroid belt and the outer belt. In particular, the onset of aqueous alteration at various heliocentric distances will provide information about formation conditions. The approach includes: obtaining new narrowband charge coupled device (CCD) reflectance spectra of main-belt and outer-belt primitive asteroids in the 0.35 to 1.0 micron spectral range; studying these spectra for fine absorption features which have been correlated with iron oxide features seen in terrestrial phyllosilicates and carbonaceous chondrites; and studying the shape and depth of these features and correlating these data with heliocentric distance to obtain information about the mineralogical products of aqueous alteration at these heliocentric distances.

### W93-70218

196-41-50

Goddard Space Flight Center, Greenbelt, MD.

#### GROUND-BASED INFRARED ASTRONOMY

Donald E. Jennings 301-286-7701

(188-44-57; 154-50-80)

The scientific objective of this program is to obtain infrared spectra of planets with a combination of the highest possible sensitivity and the best resolution. A cryogenic postdisperser, developed at Goddard Space Flight Center, has been used with the Fourier Transform Spectrometers (FTS) at the Kitt Peak 4-meter and McMath telescopes. This narrow-band focal plane instrument improves the sensitivity of the FTS in the thermal infrared by an order of magnitude. Using this instrument on the 4-meter telescope, acetylene and ethane were observed in and out of the hot spot

at Jupiter's northern latitudes. In addition, carbon-13 ethane was detected in Jupiter. With the McMath telescope carbon dioxide was observed, and hydrogen peroxide was searched for, near 8 microns. These observations were made at 0.01 cm(exp -1) resolution. A new spectrometer has been constructed to take advantage of the improved sensitivity available with modern detector arrays. A large cryogenic grating disperses the spectrum onto a 10 x 50 element array. This instrument yields another order-of-magnitude improvement in sensitivity.

### W93-70219

196-41-52

Goddard Space Flight Center, Greenbelt, MD.

#### IMAGING STUDIES OF COMETS

Malcolm B. Niedner, Jr. 301-286-5821

This RTOP provides for the operation of a small high altitude observatory, the Joint Observatory for Cometary Research (JOCR). The imaging data obtained at JOCR are both wide- and narrow-field, and principally address the interaction of comets with solar radiation and wind. Research is most effective when in situ solar wind and Interplanetary Magnetic Field (IMF) data from spacecraft are available to compare with the imagery; preparation of the facility for the upcoming pass of ULYSSES over the heliospheric poles is a key to future planning. Funding under this RTOP provides support for the operation of the observatory only. However, analysis of research results is funded by other resources. The observatory site in central New Mexico is one of the darkest sites left in the continental U.S. Wide-field photography (using the comet Schmidt camera) of more than 12 comets since 1973, including recent comets IRAS-Araki-Alcock, Giacobini-Zinner, Halley, and Bradfield, has been carried out. Analysis of some of the imagery has provided information on the interaction of comets with high-speed solar-wind streams and magnetic sector boundaries, the magnetic field strength in the tail, the injection speed of ions into the tail, pressure balance conditions across the tail, and other phenomena. Most spectacular, disconnection events (DE's) of the plasma tail were discovered in JOCR images of comet Kohoutek and have been plausibly linked to sector boundary crossings and magnetic reconnections; a catalog of DE data consisting of 72 DE's in 29 comets between solar latitudes. The DE results on sector structure may possibly represent the only actual probes of the IMF sector structure at high latitudes (until the ULYSSES mission). Recently, studies of computed (potential) coronal magnetic fields have given support to the DE comet results. DE's, helical waves, and prominent turning tail rays are seen on many of the images of Halley's Comet taken at JOCR (and elsewhere). Over 100 photographic plates of comet Bradfield (1987's) were obtained during the period August 1987 through December 1987 including a spectacular disturbance of the ion tail that lasted for at least five nights centered on October 20, 1987. A CCD system with both narrow band IHW comet filters and broad band BVRI filters attached to the 16 inch f/35 telescope has been added to the compliment of instrumentation available at JOCR. A second CCD has been placed behind a 300mm lens and comet filters to provide additional wide-field imaging capability of bright comets, including Austin and Levy in 1990. Especially significant was a series of H2O+ exposures of Austin on May 21, 1990 which showed the development of large angular excursions in the tail, tail ray development, and disconnection activity. These digital images have been deposited on video in movie format. Calibration of the CCD/filter systems and automation of the 16 inch telescope for tracking of solar system objects has been completed.

### W93-70220

196-41-54

Goddard Space Flight Center, Greenbelt, MD.

#### ADVANCED INFRARED ASTRONOMY

Michael J. Mumma 301-286-6994

The molecular constituents of planetary atmospheres and comets, and processes occurring in them, are studied through observations of their IR line spectra. High spectral and spatial resolution is utilized in order to obtain information on compositions (e.g., of cometary nuclei), structure (e.g., temperature profiles), spatially localized phenomena (e.g., hot spots) and dynamical processes (e.g., winds in planetary atmospheres). Models for

predicting and interpreting planetary and cometary spectra are developed. State of the art instrumentation is developed, including heterodyne spectrometers for Doppler-limited spectroscopy (8-30 micron range), and high resolution grating spectrometers for 1-5 micron range. Observations are conducted from ground-based and airborne observatories. Laser heterodyne spectrometers are used for ultrahigh spectral and spatial resolution studies in the mid-infrared (8 to 30 microns). The next task has two objectives. The first is directed towards validating the radial velocity method for detecting extra-solar planetary systems, by measuring the velocity stability of integrated sunlight with Fourier transform and heterodyne spectrometers. Solar-cycle related effects which are observed are compared to the 13 meter/sec Doppler reflex induced by the orbit of Jupiter, and prescriptions are developed for separating these effects. The second is to investigate the global scale thermal wave phenomena in the atmospheres of the giant planets, and to characterize these in terms of atmospheric processes or internal seismological signatures. The third task is cometary composition investigation. Observations are conducted with grating and Fourier transform instrumentation in the near infrared ( $\lambda$  less than 8 microns) from ground based observatories and from the Kuiper Airborne Observatory (KAO). The last task investigates the extended atmospheres of the Moon and Mercury by using combined spatial-spectral techniques at visual wavelengths.

**W93-70221****196-41-67**

Ames Research Center, Moffett Field, CA.

**VOLATILES IN THE SOLAR SYSTEM**

D. P. Cruikshank 415-604-4244

The objective is to obtain and analyze spectroscopic data on the surfaces and atmospheres of the volatile-rich bodies (planets, satellites, asteroids, and comets) in the outer solar system. Such information is needed to interpret spacecraft observations of the planets and satellites already made and those planned for future NASA missions to the outer solar system. The approach is to obtain astronomical observations of the planets and other bodies in the solar system with the telescopes at Mauna Kea Observatory, notably the NASA Infrared Telescope Facility, and to analyze these data using standard techniques and the body of laboratory data available for comparison. The need for additional laboratory data will be identified as appropriate.

**W93-70222****196-88-01**

Ames Research Center, Moffett Field, CA.

**IMPACT CATASTROPHISM ON THE TERRESTRIAL PLANETS**

G. C. Carle 415-604-5765

The objective of this RTOP is to develop an understanding of the effects of catastrophic impacts on planetary bodies and their processes during the span of geologic history. The approach of the RTOP is to study the effect of impacts on planetary bodies in order to evaluate the role impacts played in shaping the biota and geologic evolution of the terrestrial planets. It is apparent that what is first needed is a complete theory for the probability of occurrence of rare catastrophic impacts. By developing such a theory, we can begin to address important questions concerning a variety of geochemical and biological questions involving the early history of the terrestrial planets.

**Life Sciences SR&T****W93-70223****199-02-31**

Lyndon B. Johnson Space Center, Houston, TX.

**CLINICAL MEDICINE TECHNOLOGY WATCH**

C. W. Lloyd 713-483-7120

Development of instrumentation technologies and protocols for Space Medicine Programs as an on-going task is required as

the Allied Health Professions evolve. During lunar/Mars missions, immediate return to Earth will not be possible; therefore, appropriate medical care capabilities will have to be an integral part of these programs. Current Space Station Freedom (SSF) mission scenarios describe up to 90-day missions for a crew of four people. For The SSF Program, the Medical Sciences Division is developing a modular in-flight Crew Health Care System (CHACS), which is comprised of three components: Health Maintenance Facility (HMF) which will provide the in-flight medical capabilities, the Exercise Countermeasures Facility (ECF) which will provide the capabilities to counteract musculoskeletal and cardiovascular deconditioning, and the Environmental Health System (EHS) which will be responsible for the monitoring of the quality of the SSF internal environment. The specific objectives of CHACS are outlined in JSC 31013. The unique challenge of providing medical capabilities for SSF and future Space Medicine Programs will continue to require development of low weight, low volume, highly automated medical care based as much as possible on terrestrial medical tenets and equipment.

**W93-70224****199-02-31**

Lyndon B. Johnson Space Center, Houston, TX.

**LONGITUDINAL STUDIES (MEDICAL OPERATIONS LONGITUDINAL STUDIES)**

Larry J. Pepper 713-483-7999

The primary objective of this research is to conduct longitudinal studies (both historical and current) of health outcomes and physiological variables using medical data collected from astronauts and a control group of civil servants. The study involves individuals in a relatively closed population in an attempt to relate changes in physiological and/or pathological systems to specific factors associated with occupational exposure. Study areas of particular interest consist of: long-term adaptation mechanisms to weightlessness; changes observed in annual medical certification and periodic examinations; changes in lifestyle variables; and the effects of the occupational exposure associated with their unique occupation. Effects of these factors on the normal aging process and disease incidence is of particular interest. The approach includes: (1) input and storage of all astronaut medical exams (flight, annual, periodic illness) in a computer database; (2) collecting and storing similar information on a control group of civil servants (matched on age, sex, body size, and smoking history); (3) statistical analyses of data comparing these groups; (4) drawing conclusions as to the meaning of the analyses and what steps, if any, need be taken to improve the health outcomes; (5) cumulative evaluation of pre/post-flight physiological changes across missions; and (6) reviewing periodically to include new parameters.

**W93-70225****199-04-00**

Langley Research Center, Hampton, VA.

**SPACE RADIATION EFFECTS AND PROTECTION (ENVIRONMENTAL HEALTH)**

W. R. Hook 804-864-6055

In support of existing and future manned space efforts, including Space Station Freedom, manned GEO sorties, lunar bases, and interplanetary travel, there is a critical need to provide adequate space radiation protection measures with minimum weight penalties. As a result, comprehensive studies of the physical interactions and transport of space radiations (protons, electrons, and galactic heavy ions) with extended matter have been initiated. Because laboratory radiobiological studies suggest that high energy, heavy ions (HZE particles) possess unique radiation damage characteristics and are highly carcinogenic for chronic low exposures, such as encountered in prolonged manned space missions, present research efforts are focused upon this particular component of the space radiation spectrum. Experimentally verified models of HZE particle interaction and transport through tissue-equivalent materials are being developed in a collaborative effort involving theoreticians at Langley Research Center and experimentalists at Lawrence Berkeley Laboratory. Present research is directed toward accurately characterizing the radiation field within a thick target as to particle fluence, type, charge,

mass, energy or velocity, and direction of travel. These models are being used: (1) to develop more accurate assessments of astronaut radiation exposures and body self-shielding factors; and (2) to analyze and understand the results of radiation biology experiments.

**W93-70226****199-04-11**

Lyndon B. Johnson Space Center, Houston, TX.

**RADIATION HEALTH**

C. Yang 713-483-5583

The space radiation environment is a milieu of trapped ionizing particles, protons, and electrons from solar particle events (SPE) and high energy galactic cosmic radiations (GCR). This RTOP is devoted to long-term research to determine the characteristics of the space radiation environment and to study its health risks for manned space operations. Currently available information is sufficient for low inclination Space Shuttle orbits. However, missions involving polar orbits, a permanently manned Space Station, manned sorties to geostationary orbit, lunar bases, and piloted Mars missions require a more thorough understanding of the mixed radiation energies, charges, fluence, and the long-term biological effects. Based on knowledge obtained from previous research under this RTOP, exposure to ionizing radiation may be a limiting factor in both mission and career durations for space workers. Shielding considerations, based upon radiobiological responses, may influence significantly the detailed design and total mass of a spacecraft, especially for protection from solar particle events. To provide timely solutions to these problems in the mission planning stage, the underlying research must be conducted now. A plan is presented for research in specific areas of radiobiology and radiation dosimetry. Specific attention is given to the effects of high energy heavy ions of space since the problem is unique to NASA. A coordination effort with other NASA programs and programs of related government agencies augments the information required by NASA for radiation protection of astronauts.

**W93-70227****199-04-11**

Lyndon B. Johnson Space Center, Houston, TX.

**ENVIRONMENTAL HEALTH**

J. M. Waligora 713-483-7200

The objectives of the Environmental Health RTOP are to support: (1) research involving specification, measurement, and control of the man-made internal environment in the manned spacecraft and habitats; (2) research and technology assessment essential for the definition, development, and updating of the Space Station Environmental Health Subsystem; and (3) research to study the response of the body to deleterious levels of environmental factors that may be encountered in flight, to allow prediction of physiologic or pathologic response, and to prevent or ameliorate this response. The approach utilized to accomplish these objectives will be to: sponsor in-house and outside studies which are needed to define requirements for environmental health factors, and acceptability limits; provide the technology to detect compliance with these requirements; and finally, define the mechanism of response of the body to deleterious environmental factors and investigate potential countermeasures.

**W93-70228****199-04-14**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SPACE RADIATION**

G. A. Nelson 818-354-4401

(106-20-04)

The objectives of this RTOP are to delineate the genetic and developmental effects of high linear energy transfer (LET) radiation (similar to that found in space as cosmic ray or HZE particles) and to understand how cellular repair systems process radiation induced damage. We are using the simple animal *C. elegans* as a model system in radiobiology studies conducted at JPL and the Lawrence Berkeley Laboratory BEVALAC accelerator. Autosomal visible and lethal mutations and chromosome aberrations leading to formation of nucleoplasmic bridges and duplications of X chromosome segments are being analyzed to understand particle-induced genetic lesions. The kinetics of production of these

various lesions have been investigated as functions of particle parameters such as LET, charge, and velocity. The structures of ion-induced lethal mutants are under investigation by genetic crosses, deletion mapping, and, in the case of unc-22 mutants, by DNA hybridization techniques. Modification of mutagenesis and chromosome aberration kinetics is being tested using radiation sensitive rad mutant strains which are associated with the activities of different DNA repair pathways. Molecular biology methods are being employed to establish the existence of nematode genes homologous to human excision repair loci. The nature of these repair systems will be further investigated by the isolation of new radiation sensitive and nucleic acid metabolism mutants and construction of specialized strains. The effects of track structure and free radicals are being probed by variation of ion velocity, the partial pressure of oxygen, the use of free radical scavengers, and electron spin resonance methods. Finally, we are exploring the potential alteration of gene expression using transgenic worms containing genes linked to a heat shock promoter.

**W93-70229****199-06-11**

Lyndon B. Johnson Space Center, Houston, TX.

**SPACE HUMAN FACTORS BEHAVIOR AND PERFORMANCE**

B. J. Woolford 713-483-3701

The objectives of this RTOP are to: (1) quantify human performance capabilities and limitations and move toward quantification of man-machine engineering data, both on the ground and in flight; (2) continue to pursue state of the art technology and to advance that technology for the purpose of creating more effective and efficient tools for measuring or analyzing human performance; and (3) collect, organize, and make accessible data on space human factors so the innovative steps may be taken toward creating better interfaces in future vehicles and habitats. The approach is to: (1) implement a series of continuing tasks to identify and implement practical instrumentation packages for acquiring quantitative man-machine engineering data in various gravitational fields and under actual flight conditions; (2) continue those efforts currently defined that lead toward definitive design requirements for use as inputs to an automated crew station design; and (3) pursue feasibility studies of promising new crew interface items and methods.

**W93-70230****199-06-11**

Lyndon B. Johnson Space Center, Houston, TX.

**BEHAVIOR AND PERFORMANCE RESEARCH**

Albert W. Holland 713-483-8482

(199-22-06; 199-06-12)

This RTOP addresses the human behavior and performance issues inherent in extended-duration space missions. As space missions increase in duration and complexity, issues such as individual adaptation to extended confinement, performance of isolated teams, cognitive readiness, motivation maintenance, and psychophysiology become salient. The RTOP focuses upon individual and team selection and training, as well as improved mission design, as principal strategies for maintaining and enhancing crew psychological health, safety, and performance. The approach is to conduct applied behavioral research whose results can be rapidly and effectively utilized by space operations to resolve salient human issues. The RTOP objectives are to: (1) determine the critical factors which affect behavior and performance in spaceflight and understand the underlying mechanisms; (2) develop methods of effectively assessing behavior inflight; (3) develop and verify procedures and strategies for assessing, maintaining, and enhancing crew health and performance; (4) utilize mission testbeds and field analogs as appropriate to maintain a knowledge base consistent with the requirements of NASA Space Programs; and (5) generate program-specific deliverables such as guidelines and standards in crew training, selection, inflight support, and mission operations.

**W93-70231****199-06-12**

Ames Research Center, Moffett Field, CA.

**BEHAVIOR, PERFORMANCE AND HUMAN FACTORS**

M. M. Connors 415-604-6114

Research objectives of this RTOP are: (1) understand individual/group, organization/management, and environmental/task factors that affect group performance and well-being in an aerospace context; (2) develop better methodological techniques for studying the processes mediating effects of such factors on crew outcomes; (3) interpret and apply research results to specific problems (current or anticipated) in aerospace operations; (4) understand the role of visual and auditory cues in perception; and (5) evaluate the use of advanced simulation techniques in perceptual motor studies. Areas of particular interest are selection and training of crews, guidelines for organizing teams and the distribution of workload (both human and automated functions), techniques for measuring and monitoring performance and providing countermeasures to stressful and high-risk conditions, and methodological tools for evaluating the effects of training, standards, procedures, and intervention techniques. Methods of analysis have also failed to provide meaningful and valid results to the operational community. The research represented in this RTOP takes an integrated approach to the 'validity' problem: it uses a variety of paradigms and research environments to converge on well-rounded and operationally sound solutions to complex problems.

**W93-70232**

199-08-11

Lyndon B. Johnson Space Center, Houston, TX.  
**GENERAL BIOMEDICAL: CENTER AND HEADQUARTERS SUPPORT**

F. T. LaRochelle 713-483-8719

Long-duration manned space flight requires investigations which will certify the health of crewmembers during extended operations in microgravity and their safe return to Earth after mission activities in space. The support for broad based programs which provide enabling capabilities (including personnel) for the implementation of these investigations is included in this RTOP. The RTOP encompasses management of extensive domestic science programs, joint international ventures, and the experimental zero-g aircraft (KC-135) life science activities.

**W93-70233**

199-14-12

Ames Research Center, Moffett Field, CA.  
**CARDIOPULMONARY PHYSIOLOGY**  
A. R. Hargens 415-604-5746

The overall objective is to develop an understanding of the cardiopulmonary and fluid-electrolyte changes occurring with spaceflight and simulated microgravity. Specific aims are to: (1) determine underlying mechanisms; (2) determine whether specific cardiovascular risks occur with short- and long-term microgravity exposure; (3) develop and test appropriate models and countermeasures to prevent or treat cardiopulmonary deconditioning; and (4) develop and implement appropriate spaceflight experiments. The approach in accomplishing these objectives will involve ground-based studies on both human and animal subjects. Specific activities will include: (1) determining effects of exercise interventions on deconditioning; (2) exposing humans to horizontal and head-down bedrest and water immersion to study mechanisms of deconditioning; and (3) testing procedures, devices and drugs to prevent and counteract deconditioning. Results should lead to: (1) a better understanding of mechanisms of cardiopulmonary deconditioning; (2) better devices and procedures for modifying deconditioning effects; and (3) specific spaceflight experiments. Results of proposed studies will improve flight safety and understanding of spaceflight risks. This research will also provide access to flight for a broader segment of the population and will use microgravity to expand understanding of cardiopulmonary/fluid-electrolyte function and autonomic nervous system control of the cardiopulmonary system.

**W93-70234**

199-16-12

Ames Research Center, Moffett Field, CA.  
**NEUROSCIENCE (BIOMEDICAL)**  
R. B. Welch 415-604-5749

Exposure to altered gravitational environments (microgravity, hypergravity, partial gravity, and centrifugal forces) causes initial

disruption of perception and perceptual-motor control, with serious consequences for the efficiency, health, and safety of astronauts during missions and upon return to Earth. Eventually, however, these deficits tend to disappear as the result of adaptation. It is important to understand the nature of the adaptive process so that it can be facilitated and because the changes necessary for normal functioning in altered g usually result in disruptive and disabling after-effects back in 1g. It is even possible that these after-effects are irreversible if exposure to the unusual gravitational environment has been sufficiently long. The major objective of the research is to characterize the short- and long-term effects of exposure to altered g (real or simulated) on hand-eye coordination, perception, vestibular-ocular control, and locomotion and posture, and to understand the neurochemical, physiological, and anatomical bases of adaptation to these environments. Also of interest are the effects of atypical gravitational forces on neonatal development and the occurrence of 'critical periods'. Knowledge gained from the research may be used as the basis for behavioral and/or neuropharmacological countermeasures to minimize specific functional deficits that astronauts would otherwise suffer.

**W93-70235**

199-18-12

Ames Research Center, Moffett Field, CA.  
**REGULATORY PHYSIOLOGY (BIOMEDICAL)**  
J. Vernikos 415-604-3736  
(199-14-12; 199-16-12)

The objective is to determine the integrative mechanisms regulating physiological adaptation to space. To accomplish this objective, ground-based simulation research designed to investigate operational factors and basic mechanisms will be conducted. All research will be conducted in man as much as possible and will include animal studies when necessary. The physiological responses induced by spaceflight will be simulated using immersion, horizontal, or head-down bedrest. Specific activities will include: (1) the understanding of the mechanisms and development of countermeasure options for the impaired thermoregulation in deconditioned subjects during exercise; (2) the effect of gravity on the regulation of circadian rhythms; and (3) the endocrine and fluid and electrolyte mechanisms involved in the adaptation to head-down bedrest and the response to pharmacological agents. Results will contribute to EVA suit technology requirements, to the understanding of the effect of gravity on homeostatic mechanisms, and to the development of safer and more effective therapeutic options.

**W93-70236**

199-26-11

Lyndon B. Johnson Space Center, Houston, TX.  
**BONE MINERAL METABOLISM AND MUSCLE PHYSIOLOGY**  
M. Jaweed 713-483-7269  
(199-18-11; 199-14-11)

The overall goal of the RTOP is to understand the physiological changes in the musculoskeletal system of astronauts, occurring due to long-term exposure to microgravity. The research effort is directed towards elucidating the pathogenesis associated with muscle atrophy and bone demineralization and to develop safe and effective physical, physiological, nutritional, pharmacological, and biomechanical countermeasures to maintain the musculoskeletal integrity and function. This research is also focused to trace the course of bone and muscle recovery after astronauts' return to the 1-g environment, so as to afford protection against the potential hazards of osteoporosis and muscle injury. Overall, this research program is geared to maintain functional capacity of the astronauts and to develop safeguards against potential hazards both in 0-g and 1-g environments. The program entails a comprehensive evaluation of bone demineralization and muscle atrophy and their prevention in human subjects. Primarily, non-invasive or semi-invasive biochemical, histochemical, physiological, nuclear magnetic resonance (NMR), tissue culture, and radiological methods will be employed to define the loss of mass and function, decreased vascularity, altered regeneration and increased vulnerability to damage. The studies will be conducted with the Space Transportation System (STS), BMAC, EMTC, and MTC missions.

**W93-70237****199-26-12**

Ames Research Center, Moffett Field, CA.  
**MUSCULOSKELETAL (BIOMEDICAL)**  
 R. E. Grindeland 415-604-5756  
 (199-40-42)

The long-range goal is to understand the process of musculoskeletal weakness and wasting in space in order to reduce or prevent their occurrences by rational countermeasures. The fundamental concern for tissues designed to support weight is a reduced function in space and injury on return to earth's gravity. Specific goals are directed toward characterizing the time course, morphology, biochemistry, biomechanics, and physiology of the adaptation of support structures to changes in simulated weightlessness. The focus is entirely on bone, muscle, and connecting ligaments and tendons. However, there is necessarily an overlap with other biomedical areas, especially cardiovascular, endocrine, and neural because of the functional interdependence of support structures with these systems. Inherent in efforts to understand the changes that occur with disuse are the development and validation of methods to monitor the process. A basic science approach is primarily used since the most effective methods for preventing and treating muscle and connective tissue atrophy, as well as bone demineralization, will be derived from a knowledge of their mechanisms. Experimental models are designed to disrupt, and/or evaluate the support function of the musculoskeletal system in whole animals or tissues. A detailed mechanistic approach, combining animal and human research, is used. Studies are coordinated with flight projects to validate the models for the zero gravity environment. Current preventive measures included in this research are exercise, centrifugation, nutrition, and pharmacologic agents.

**W93-70238****199-26-14**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**MUSCULOSKELETAL**  
 R. H. Selzer 818-354-5754

The objective of this task is to develop and validate methods to measure muscle volume change associated with disuse. A technique is currently under development to measure lower leg muscle volume from magnetic resonance images. This technique is designed for use in bedrest studies, as a tool to evaluate muscle atrophy countermeasures or for pre- and post-flight monitoring of muscle. The plan for fiscal year 1993 is to complete development and validation of the muscle volume measurement method and then to carry out a technology transfer strategy that would make the method accessible to other NASA Center users. This strategy involves implementation of the method on a PC-based stand-alone computer, in place of the mini-computer currently in use.

**W93-70239****199-40-21**

Lyndon B. Johnson Space Center, Houston, TX.  
**CELL AND DEVELOPMENT BIOLOGY**  
 C. Sams 713-483-7160

Space flight has been demonstrated to cause a variety of alterations in biological organisms. Analysis of these adaptive processes is frequently complicated by the number of interacting systems contributing to the observed physiological changes. The use of cell biology methods frequently enables reduction of complex problems to levels that are approachable for scientific investigation. Since biological adaptation occurs as a consequence of biochemical alterations in cellular processes, detailed knowledge of basic cell function in the terrestrial and microgravity environments will further understanding of the more complex processes occurring in man. The goal of this program is to develop and support systems and procedures for the application of cellular/molecular techniques to the investigation of space flight relevant biological problems. The projects included in this RTOP are basic research efforts designed to improve the understanding of the biological changes observed in microgravity. The focus of this RTOP is to determine the molecular mechanisms which are responsible for the influence of gravity on cellular function. This will include the examination of both direct effects of gravity on the cellular machinery (e.g., signal transduction pathways, cytoskeletal structures) and indirect or

environmental effects (cell dispersion effects, transfer of nutrients or effector molecules, etc.). Several tasks examine the fundamental mechanisms of cellular systems which exhibit a sensitivity to the space flight environment or a related environmental factor (e.g., stress, hypokinesia). The understanding of these mechanisms at the cellular and molecular level may provide a basis for the analysis of space flight induced physiological changes within higher organisms.

**W93-70240****199-40-22**

Ames Research Center, Moffett Field, CA.  
**CELL AND DEVELOPMENTAL BIOLOGY**  
 R. A. Grymes 415-604-3239  
 (199-40-32; 199-40-21; 199-40-42)

The objectives of this program are to further our understanding of the effects of altered gravities on mammalian cells and the mechanisms of the cellular responses. Gravity modulation of cell behavior will be studied in the context of growth factor responsiveness. Various indices of cell behavior will be studied, including changes of the internal supporting architecture of the cell, alterations of proliferation potential, and modification of genetic information utilization. The approach of this program centers on the measurable changes in response that occur following the exposure of viable cells to altered gravities. The model system chosen comprises cells of the dermis and epidermis (skin). Centrifugation and clinostat treatment will be used as laboratory equivalents of hyper- and microgravity.

**W93-70241****199-40-32**

Ames Research Center, Moffett Field, CA.  
**INTEGRATIVE BIOLOGY**  
 C. E. Wade 415-604-3934

Living systems have evolved in a gravitational field and are regulated to function within tightly controlled limits. Asymmetries in the environment (including presumably gravity) result in disturbances in these regulatory mechanisms to which living systems adapt or evolve (or if not, become extinct). These regulatory mechanisms, in their broadest sense, involve those controlling the physiological baseline, characterized by circadian and other rhythmic periodicities, and the ability to respond appropriately to stimuli, controlled by negative feedback networks. These in turn depend at the organ level on the regulation of calcium-dependent stimulus/secretion coupling and at the cellular level on transcription/translation mechanisms. The objective of the Integrative Biology RTOP is to address key issues that will lead to an understanding of how gravity affects these mechanisms regulating homeostasis, adaptation, and the ability of living systems to respond to internal and external signals. Research will focus on the role of gravity in circadian and homeostatic regulation. While study of the physiological effects of hypogravity is primary, ground-based hypergravity studies will remain an essential part of the program.

**W93-70242****199-40-42**

Ames Research Center, Moffett Field, CA.  
**STRUCTURAL BIOSYSTEMS**  
 E. M. Holton 415-604-5471  
 (199-40-22; 199-40-12)

The structural Biosystems Research Program will address key issues that will lead to an understanding of the biological processes regulating structural support systems as well as the role of gravity in modulating these processes. This program sponsors research focused on the influence of gravity primarily on musculoskeletal cell structure and function and on the use of altered gravity as a probe to explore the plasticity of the musculoskeletal system. The structural biosystems program supports research which employs in vitro and animal model systems to investigate structure and function from the subcellular to organismic level. The program takes advantage of both actual and simulated spaceflight environments to study physiological effects of hypogravity. A major emphasis of the program is to use hypogravity to understand the role of gravity in modulating mechanisms and responses of the musculoskeletal system. Multiple

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

approaches are required to understand how structural tissues are created for support of organisms (cellular, invertebrate, and vertebrate systems) both on Earth and in space. Mineralizing bone cell cultures, muscle cultures, and invertebrate biomineralization will be used to elucidate the genetic, molecular, and cellular mechanisms. The loaded and unloaded musculoskeletal system of growing rats will be studied to characterize the development of matrix in muscle and bone and mineral composition of bone.

### W93-70243

199-40-62

Ames Research Center, Moffett Field, CA.

#### FLIGHT RESEARCH

C. E. Wade 415-604-3934

The objectives of this RTOP are to support research directly related to flight experiment and to support scientific studies and planning activities in gravitational biology.

### W93-70244

199-40-72

Ames Research Center, Moffett Field, CA.

#### FLIGHT RESEARCH

R. W. Ballard 415-604-6748

The objectives of this RTOP are to support research directly related to an accepted flight experiment and to support scientific studies to improve existing flight hardware. The approach to this RTOP will be to conduct engineering studies for improvements to life sciences laboratory equipment hardware in order to make cost efficient second generation equipment.

### W93-70245

199-52-11

Lyndon B. Johnson Space Center, Houston, TX.

#### CHARACTERISTICS OF VOLATILES IN INTERPLANETARY DUST PARTICLES

Everett K. Gibson, Jr. 713-483-6224

The goal of this study is to investigate the elemental and molecular compositions of volatiles and the chemical state of carbon present in interplanetary dust particles (IDP's). Interplanetary dust is important to studies of the origin of the solar system because it is the material from comets and asteroids, the smallest surviving bodies from the early solar system. The investigation will obtain compositional information about the volatiles present at the time of formation of these primitive particles along with obtaining accurate and reliable bulk carbon abundances in a group of IDP's and obtain spatial distribution, the phase compositions and proportions, and the degree of crystallinity of the carbonaceous material. Because of the possibility that the dust particles may have a cometary origin, their analysis could provide information about the volatiles associated with the dusty component present in comets. Exobiological interest in cosmic or interplanetary dust particles stems from their potential for contributing to the elucidation of the cosmic history of the organogenic elements (i.e., H, C, N, O, S, and P) that make up all living systems. Therefore, the study of IDP's will enhance our understanding of comets, asteroids, primitive meteorites, and the solar system along with providing an increased knowledge of the interstellar medium.

### W93-70246

199-52-12

Ames Research Center, Moffett Field, CA.

#### COSMIC EVOLUTION OF BIOGENIC COMPOUNDS

T. Bunch 415-604-5909

(199-52-22; 199-52-32)

The objective of this RTOP is to understand the history of biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and the early solar system. The following lines of inquiry are pursued: (1) trace the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determine the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system in order to develop theories about the formation of the solar system and the prebiotic evolution and origin of life; and (3) determine the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course

of events during the formation of the solar system and the component bodies. The approaches of the RTOP are to: (1) characterize plausible chemical reaction pathways for candidate interstellar organic species by quantum chemistry methods; (2) obtain laboratory infrared spectra of artificial molecular mixtures for comparison with astrophysical observations; and (3) analyze U-2 aircraft-collected interplanetary dust particles and long duration exposure facility (LDEF) impact crater residues for biogenic and inorganic elements and characterize their phase structures.

### W93-70247

199-52-22

Ames Research Center, Moffett Field, CA.

#### PREBIOTIC EVOLUTION

S. Chang 415-604-5733

(199-52-12; 199-52-32)

The objective of research in prebiotic evolution is to understand how the evolutionary sequence leading from simple chemicals to living systems occurred during the development of Earth and other planets. The approaches taken to meet the objective fall into two major study areas, each of which involves the use of both laboratory experiments and computer simulations: (1) the consequences of planetary evolution on the physical environments of the Earth and planets; and (2) the evolution of molecules and molecular systems under the constraints imposed by the physical environment, and by the appearance, a posteriori, of living systems on Earth. Studies of planetary evolution assess the importance of the physical-chemical processes associated with the dynamic development of planetary surfaces, on both global and microenvironmental scales, which could have been involved in, or provided constraints on, the development of living systems on Earth and other planets. Studies of molecular evolution focus on the energetics, dynamics, and synthesis of chemicals and chemical systems in order to elucidate feasible mechanisms by which these systems acquired biological attributes within the constraints of the environment.

### W93-70248

199-52-32

Ames Research Center, Moffett Field, CA.

#### THE EARLY EVOLUTION OF LIFE

D. J. DesMarais 415-604-3220

(199-52-22; 199-52-82)

The objective of this RTOP is to understand the nature and evolution of primitive organisms and to relate such evolution to those forces which guided the evolution of the planet. The approach of the RTOP will be to explore the mechanisms, processes and environments associated with the early evolution of life on Earth as an approach to understanding life elsewhere in the Universe. Two repositories of evolutionary information are examined: the molecular record in living organisms and the geologic record in rocks. Biological studies address the early evolution of the complex systems that constitute the essential attributes of life. Energy transduction is being studied by examining the Archaeobacteria (e.g., extreme halophiles, acidophilic thermophiles) and comparing their properties with those of eubacteria. The development of oxygen-requiring pathways in lipid synthesis is investigated both in eubacteria and in eukaryotes. Geologic studies seek to elucidate earlier biochemistries through analyses of ancient biological material preserved in stromatolitic rocks. The paleoenvironment (e.g., its structural setting and the chemical composition of its ocean and atmosphere) is also being described.

### W93-70249

199-52-52

Ames Research Center, Moffett Field, CA.

#### SOLAR SYSTEM EXPLORATION

G. C. Carle 415-604-5765

(199-52-12; 199-52-22; 106-60-05)

The objective of this research is to provide specific information on the elemental and chemical composition, mainly in respect to the biogenic elements, of the atmospheres and surfaces of solar system bodies including planets and their satellites, comets, asteroids, meteorites, and dust in space. This information is essential for selecting or devising the most appropriate model for the evolution of the solar system and for each of the investigated



bodies. Further, it will provide a basis for understanding the conditions necessary for the origin of life by comparisons of the evolution and chemistries of these bodies. The approach will be to define and develop improved methods, instrumentation, and experiments for in situ chemical analyses of the selected species associated with the bodies to be investigated. Special emphasis is directed to development of the gas chromatographic approach since it is now proven to be among the most effective means for measuring complex, gaseous mixtures. Improvements in gas chromatographic techniques, e.g., multiplex chromatography, and components, e.g., detectors and columns, will be rigorously explored. Other techniques and experiments for extraterrestrial studies related to the understanding of the origin of life will be investigated and developed for other flight opportunities as appropriate, e.g., Space Station and lower-Earth orbiters.

**W93-70250****199-52-54**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**EXO BIOLOGY INTACT CAPTURE TECHNOLOGY DEVELOPMENT**

P. T. Tsou 818-354-8094

The ultimate objective of our endeavor is to return to Earth intact particles for detailed laboratory analyses. Unlike destructive dust capture techniques, intact capture can preserve the chemistry, biogenic elements, and petrology of the captured particles. In 1988, Exo-ICE, a successful proposal to the Space Station Attached Payload AO made use of one level of the passive intact capture technology that was laboratory-proven at the time of the proposal submission. In this plan, supportive activities toward the overall development of this technology shall be pursued with an emphasis toward the documentation of achievements thus far.

**W93-70251****199-52-82**

Ames Research Center, Moffett Field, CA.

**EXPLORATION EXO BIOLOGY**

D. L. DeVincenzi 415-604-5251

(199-52-52)

The objective of this RTOP is to define Exobiology science objectives for the Space Exploration Initiative (SEI) missions to the Moon and Mars, with emphasis on Mars. This will involve determining if Mars harbors an extant or extinct biota or evidence for prebiotic chemical evolution. The approaches of this RTOP will include the following: programmatically-oriented activities to define exobiology science objectives and payloads for SEI missions; research activities to characterize the physical and chemical environment of Mars; development of Earth models for extant and extinct life on Mars and Mars analog environments; and study of applicability of telepresence concepts to exobiological exploration of planets. In addition, ground-based and mission data will be analyzed in order to identify Mars landing sites optimized for exobiology objectives.

**W93-70252****199-55-19**

Goddard Space Flight Center, Greenbelt, MD.

**ADVANCED PROGRAMS THEORETICAL BIOLOGY**

John E. Dorband 301-286-9419

We are pursuing a new and unique approach to understanding the behavior of natural environmental systems - creating algorithms to simulate evolutionary dynamical systems as cellular dynamata on massively parallel processor arrays. The origin of life is perhaps the most challenging natural phenomenon to approach in this manner. To explain the origin of life we must explain the highly improbable accumulation of 'biological information' into primitive systems which have the characteristics of living organisms: bounded open dissipative (metabolic) systems which self-replicate with diversity. The hot spring model proposes that a sequence of environments within Archean submarine hot spring systems provided the constraints in which the prebiotic synthesis, self-organization, and early evolution of living systems occurred. We propose to create models of self-organization in the following: (1) a collection of autocatalytically interacting molecules within a primitive cell in a hot spring fracture; (2) a collection of such replicating cells within a fracture through which fluid flows (an

Eigen 'evolution' reactor); and (3) a collection of cells in an emerging laminated microbial community at the interface between the hot spring environment and the sea floor. We have created a UNIX-based C program with which such simulations can be readily studied on the MasPar, producing 3D video visualizations.

**W93-70253****199-61-11**

Lyndon B. Johnson Space Center, Houston, TX.

**CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELSS) PROJECT**

D. L. Henninger 713-483-5034

Missions scenarios envisioned for the Space Exploration Initiative are very long-duration missions and will last months to years at a time. Human life support systems must minimize resupply from Earth and enhance the self-sufficiency of crews at remote locations on the Moon and Mars. These life support systems will make use of higher plants, microorganisms, and physiochemical processes for the production of water, food, and oxygen while converting carbon dioxide and recovering resources from waste materials. Development of a Controlled Ecological Life Support System (CELSS) will be a pivotal capability for missions to explore the solar system. Research within the CELSS Program began several years ago and is now able to capitalize on much of that research by moving into the area of technology development. The CELSS Breadboard Project was designed to examine and verify plant production under tightly controlled conditions at a sufficiently large scale. Development of test bed facilities must be continued for integration of all life support components and subsystems, both biological and physicochemical. Efforts must continue to design a human-rated life support systems test facility. This RTOP is to continue life support research and development and to continue development of test bed facilities.

**W93-70254****199-61-12**

Ames Research Center, Moffett Field, CA.

**BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELSS)**

R. D. MacElroy 415-604-5573

(199-61-23)

The objective of this RTOP is to support the scientific experiments, the technological investigations, and potential flight experiments necessary for the development of bioregenerative life support systems. Investigations are directed toward the practical use of the functions performed by higher plants, algae, microorganisms, physical-chemical processes, and mechanical devices for human life support. Of particular interest are the functions that produce potable water, food and oxygen, absorb carbon dioxide, and process waste materials in orbit or on planetary surfaces. The goal is to ensure recycling materials by regeneration of consumables needed for crew support. Included also are studies of the control and the efficiency of such bioregenerative systems. The approach involves study of the rates at which organisms or physical-chemical devices produce or consume biomass, food, oxygen, carbon dioxide, potable water, and fixed nitrogen in response to changes in environmental variables such as temperature, atmospheric gas composition, light (intensity, duration, and quality), humidity, wind speed, and the composition of nutrient medium. These investigations are also conducted to improve the methods available for increasing system efficiency, stability and control through automated sensing, data collection, and data interpretation. The data collected form a science-requirements base for the use of the Controlled Ecological Life Support Systems (CELSS) Projects and the design of experiments to be conducted in space.

## Solar Terrestrial Mission Operations and Data Analysis

**W93-70255****370-03-00**

Goddard Space Flight Center, Greenbelt, MD.

**ARCHIVAL TASK FOR THE EQUATORIAL SAN MARCO D, AE AND DE SATELLITE MISSIONS**

R. A. Hoffman 301-286-7386

The objective is to archive on well documented media the processed experimental data from the San Marco D and AE satellites and the telemetry data from Dynamics Explorer 1 (DE 1) satellite. The bulk of this RTOP will be devoted to processing data from the San Marco EFI, IVI and WATI experiments to an agreed-upon common data rate and then merging these files, together with data supplied by the European San Marco experimenters, onto a set of National Space Science Data Center (NSSDC) approved media. The merging will be done at the University of Texas at Dallas via a Goddard Space Flight Center (GSFC) grant from these funds. Secondary tasks will be the clean-up of the final files of the AE data bases and the completion of the optical disk copying of telemetry data for DE 1.

**Astrophysics Mission Operations and Data Analysis****W93-70256****399-18-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**HIPPARCOS VLBI**

R. A. Preston 818-354-6895

The ESA satellite HIPPARCOS will determine the positions, proper motions and trigonometric parallaxes of 100,000 optical stars with unprecedented accuracy. We plan to tie the HIPPARCOS observations to the JPL Very Long Baseline Interferometry (VLBI) celestial reference frame, which is composed of the radio cores of distant quasars and galaxies. This will allow HIPPARCOS studies of stellar and galactic dynamics to be linked to a nearly inertial reference frame, and will result in a common optical/radio high precision celestial reference frame. The HIPPARCOS and VLBI reference frames will be tied together by radio stars which can be positioned directly in both frames. In the last year, we have continued an astrometric VLBI observational program on 12 radio stars, mostly of the RSCVn class of close binaries (approximately 0.001 second separation), using phase-referencing techniques. Our observations have also provided significant new information on stellar radio emission mechanisms.

**W93-70257****399-20-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ENERGETICS OF INTERSTELLAR CLOUDS**

W. D. Langer 818-354-5823

The purpose of this program is to study the energy balance in interstellar clouds. The structure and evolution of interstellar clouds and the star formation mechanism within them are strongly influenced by the energy balance and chemical processes characterizing the cloud. We will obtain Cosmic Background Explorer (COBE), Infrared Astronomy Satellite (IRAS), HI and CO (isotopic) surveys of nearby interstellar clouds, and use these, along with theoretical models, to determine the gas and grain properties, influence of grains on the energy and chemistry, and energy and chemical balance. Among the most important information needed for understanding these processes is identification of heating and cooling sources, radiation field, and chemical and dust composition. We will study clouds with a wide range of radiation fields and include core-halo and clumped structures. We will expand and develop numerical models for the chemistry and structure using stratified isotopic chemistry models, including radiation extinction and dust emission, and radiative transfer for gas emission. We will also develop analogous codes for clouds with clumpy structures.

**W93-70258****399-20-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**IPAC ASTROPHYSICS DATA SYSTEM (ADS) SUPPORT**

J. C. Good 818-584-2939

Infrared Processing and Analysis Center's (IPAC's) support of the Astrophysics Data System (ADS) Project involves System Engineering, operation of the ADS system, and technical support of the ADS service nodes. IPAC is the Operations Center for ADS. As such it provides logistical and consulting support for the Project as a whole and individually for each of the ADS service nodes. IPAC is responsible for the health and welfare of the operational system, and the ADS Operations Manager at IPAC has authority over operational decisions that affect the system. The Systems Engineering of the ADS is controlled through IPAC. The ADS System Scientist at IPAC has authority over all technical aspects of project development.

**W93-70259****399-20-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**NASA/IPAC EXTRAGALACTIC DATABASE**

G. Helou 818-584-2928

The purpose of the NASA/IPAC (Infrared Processing and Analysis Center) Extragalactic Database (NED) is to provide an on-line database service for supporting extragalactic research. The database will contain up-to-date references to the literature, abstracts from the major journals, and a master directory of objects, their names and cross-identifications. Astronomical data on these objects will be collected from the literature and entered into the database. A convenient, user-friendly interface is a requirement for efficient use of the database. The database and interface are set up and maintained on the IPAC computers, and are made available by remote access over electronic computer networks to the astronomical community at no cost to the user. These services are also accessible world-wide.

**W93-70260****399-20-01**

Ames Research Center, Moffett Field, CA.

**CENTER FOR STAR FORMATION STUDIES**

D. J. Hollenbach 415-604-4164

The objectives of this RTOP are to, first, undertake a unified theoretical analysis of the problem of star formation and, second, to theoretically study the evolution of dust in the interstellar medium. The approach of this RTOP is to show that the interrelated theoretical problems cannot be attacked in isolation, but must be approached from the viewpoint of overall consistency with advances in other fields. Our comprehensive investigation includes studies of patterns of star-forming regions on galaxy wide scales; dynamics, structure, energetics, and chemistry of the interstellar medium; details of the fragmentation of molecular clouds and gravitational collapse of their dense rotating cores; possible differences in the formation of high and low mass stars; formation and evolution of protostars and nebular disks; mechanisms of planetary system formation and disk dispersal; the origin of bipolar flows and their effect on the surrounding gas and dust; the effect of the radiation from young stars on circumstellar material; the origin of water masers and Herbig-Haro objects associated with star-forming regions; the influence of strong shock waves on the abundance, composition and the distribution of interstellar dust; the role of circumstellar polycyclic aromatic hydrocarbons (PAH's) in the formation of C-stardust; and the formation of interstellar icy grain mantles.

**W93-70261****399-50-00**

Ames Research Center, Moffett Field, CA.

**THE NATURE OF INTERSTELLAR DUST, ICES AND POLYCYCLIC AROMATIC HYDROCARBONS**

L. J. Allamandola 415-604-6890

The objective of this RTOP is to analyze spectroscopic data taken from spacecraft in the vacuum ultraviolet and infrared spectral regions to study the chemical composition and physical state of interstellar dust, ices, and polycyclic aromatic hydrocarbons (PAH's). The approach of this RTOP is to use laboratory-produced data to direct the observing strategy used on satellites with



spectroscopic capabilities in the vacuum ultraviolet and infrared spectral regions. The laboratory data we have on PAH's, interstellar dust, and ices show very specific signatures of these materials in spectral regions never measured. These regions will be studied with soon-to-be-launched spacecraft. This laboratory data, and other experiments we can perform as needed, will be used to interpret the observations from these spacecraft. This analysis affords the potential of (1) discovering new and important interstellar molecules; (2) determining the deuterium distribution in interstellar ices and PAH's; and (3) uniquely identifying some specific interstellar PAH's based on their far-IR spectra.

## EOS Data Information System

**W93-70262**

**428-81-04**

Goddard Space Flight Center, Greenbelt, MD.

### **A 4D DATA ASSIMILATION FOR EOS COMPUTER SUPPORT**

Richard B. Rood 301-286-8203

The objective of this RTOP is to provide computer resources for Earth Observing System (EOS) related data assimilation. This RTOP provides money for two items: (1) a Central Computer Facility, which provides super computer access for data assimilation; and (2) a Local Network, where workstations and ancillary equipment are provided for assimilation activities. Support is also required for personnel to maintain the network.

**W93-70263**

**428-81-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **ROLE OF AIR-SEA EXCHANGES AND OCEAN CIRCULATION (COMPUTING)**

W. T. Liu 818-354-2394

(429-81-10)

This is an interdisciplinary science investigation of NASA's Earth Observing System (EOS) program. The objective is to study the role of ocean circulation and the ocean-atmosphere exchanges in affecting global climate changes. Methods to compute ocean surface heat, momentum, and water fluxes using satellite data are being developed and improved. The responses of the atmosphere and ocean to these surface forcings, as related to the storage and transport of heat and greenhouse gases, will be examined. Tropical ocean-atmosphere interaction will be studied first. The energy and hydrologic balances of the coupled ocean-atmosphere system will be examined. An eddy-resolving general circulation model to assimilate satellite data and to provide a realistic four-dimensional description of ocean circulation will be developed. We will extend and join our funded studies in satellite missions such as Environmental Research Satellite (ERS)-1, NASA Scatterometer (NSCAT), Topex/Poseidon, and Tropical Rainfall Measuring Mission (TRMM). We will utilize our established participation and leadership in the field campaigns, the monitoring programs, and the modeling efforts of Tropical Ocean and Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE). We will draw upon operational satellite data and will follow closely the development of data systems such as International Cloud Climatology Project (ISCCP), Wetnet, Global Precipitation Climatology Project (GPCP) and Surface Radiation Budget (SRB) project. We will contribute to the Global Energy and Water Cycle Experiment (GEWEX) as soon as it is ready to address problems over the ocean. These studies will pave the way for the era of EOS platforms.

**W93-70264**

**428-81-16**

Goddard Space Flight Center, Greenbelt, MD.

### **GLOBAL HYDROLOGIC CYCLE**

William K.-M. Lau 301-286-7208

(429-81-16)

The objective of this RTOP is to improve our understanding

of the physical mechanisms of atmospheric hydrologic processes; the role of hydrologic processes in large scale ocean-atmosphere-land interaction leading to natural fluctuation of the global climate system over a variety of time scales; and the role of land surface processes, including storage, in the global hydrologic cycle, with emphasis on the interaction and integration of regional to global scales. The approach is to make extensive use of data collected from existing satellite missions and from Earth Observing System (EOS); to use results obtained for the pre-EOS phase to provide guidance for instrument design in the launch phase and to further our understanding of global hydrologic processes through model development and data analysis; and to emphasize a synergistic approach based on analysis of data from space and non-space platforms as well as modeling.

**W93-70265**

**428-81-26**

Goddard Space Flight Center, Greenbelt, MD.

### **BIOSPHERE ATMOSPHERIC INTERACTIONS**

Piers J. Sellers 301-286-4173

A global atmosphere general circulation model will be forced with surface data sets derived from Advanced Very High Resolution Radiometer (AVHRR) data to calculate surface-atmosphere fluxes of energy, heat, water, and CO<sub>2</sub>. Regional ecology models will be developed.

**W93-70266**

**428-81-36**

Goddard Space Flight Center, Greenbelt, MD.

### **EOS IDS, EOSDIS MONEY**

Mark R. Schoeberl 301-286-5819

The investigation is a two-component effort to characterize both the short- and long-term stratospheric changes which have occurred and will occur over the period beginning with Nimbus 7 observations in late 1978, continuing with the Upper Atmosphere Research Satellite (UARS) and on through the EOS observing period. The first part of this proposal involves the generation of climatological data sets for ozone, temperature and trace gases (N<sub>2</sub>O, CH<sub>4</sub>, NO<sub>2</sub>, NO etc.). These data sets will be made available to the EOSDIS (EOS Data and Information System) during definition phase for use by other interdisciplinary and instrument investigators. The second part of the investigation is to study natural and anthropogenic changes in the stratosphere as revealed by the climatological data sets. In particular, we are interested in being able to separate natural and anthropogenic processes in order to better assess the exact magnitude of anthropogenic changes and understand the natural chemical/dynamical/radiative interaction and feedback processes within the stratosphere. We propose to use the data assimilation model and other 2- and 3-D models to facilitate the generation of the climatological data sets mentioned above as well as undertake the theoretical investigations. This RTOP area concerns the upgrade of computer facilities to accomplish this investigation.

**W93-70267**

**428-81-72**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **PROJECT TO INTERFACE MODELING: EOSDIS ACTIVITIES**

R. W. Zurek 818-354-3725

(429-81-72)

The unique observational capabilities provided by the Earth Observing System (EOS) program have the potential for driving major improvements in climate models at the global and regional scale. The National Center for Atmospheric Research (NCAR) EOS Project to Interface Climate Modeling on Global and Regional Scales with EOS Observations is a selected interdisciplinary investigation designed to work synergistically between the selected EOS measurement capabilities, detailed research on the physical mechanisms of climate change, and the development of global climate and global change models. The emphasis is on surface and atmospheric processes related to the hydrological cycle and to atmospheric circulation and radiation. In parallel with the National Center for Atmospheric Research's climate modeling program, the project will focus on the sensitivity of climate models to EOS observations, the framework for the assimilation of EOS data needed for climate models, the application of EOS data sets to

model validation and as model boundary conditions, and development of climate model parameterizations and diagnostics that are more compatible with remotely sensed (satellite) data than those at present. The project will also carry out prototype applications of currently available data sets to improve our framework for relating EOS data to climate models. New approaches will be developed and applied to the analysis of satellite data, as applicable to the EOS sensors and for testing model simulations. New and modified approaches to the archiving and the visualization of global satellite data and model simulations will also be developed as needed. Activities include (1) documentation and provision of prototype data sets and of model-generated fields as required; and (2) implementation, documentation, and support of interactive software tools for the analysis and display of satellite remote sensing data and for the comparison of such data with climate model simulations.

**W93-70268****428-81-80**

Goddard Space Flight Center, Greenbelt, MD.

**EOS DIS FOR IDS ON BIOGEOCHEMICAL FLUXES AT AIR/SEA INTERFACE**

Anne M. Thompson 301-286-2629

The objective of this RTOP is to outline a system for satellite data input, model analysis and output to be delivered to EOS DIS (Data and Information System). Pre-launch of these satellites will use existing data sets (e.g., Coastal Zone Color Scanner, CZCS) and post-launch data from MODIS (Moderate Resolution Imaging Spectrometer), STIKSCAT, AMSU (Advanced Microwave Sounding Unit), MOPITT/TRACER, and other instruments. Data processing for the task is likely to take transfer velocities and dissolved trace gas distributions from other members of our EOS team to produce flux maps. Fluxes will be used in the photochemical model to produce lower tropospheric distributions of DMS, SO<sub>2</sub>, and CO. Another objective is to use existing data sets and models to make N calculations on a grid appropriate for GCM (General Circulation Model). Monthly averaged data sets are to be used initially. The current tropospheric 1-D model will be the basis for N calculations. This RTOP deals with the computational requirements of this investigation. It will include updating of hardware and software to accomplish on a large grid (N computations) what we have been doing in a single computation mode on a VAX 11/780. Hardware choices will be made to insure compatibility and efficient data transfer among EOS team members, both at GSFC and WHOI (Woods Hole Oceanographic Institute).

**W93-70269****428-81-94**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL ASSESSMENT OF ACTIVE VOLCANISM**

D. C. Pieri 818-354-6299

Funding is requested under this RTOP for computing support for the Earth Observing Systems (EOS) Volcanology Interdisciplinary Science Team activities at the Jet Propulsion Laboratory (JPL). Computing support under this RTOP will be directed toward algorithm development for the following activities: (1) remote detection of volcanic eruptions by thermal anomaly recognition; (2) remote determination of surface temperature distributions of active lava flows; and (3) determination of long-term thermal energy budgets for active volcanoes. Progress has been made on a related RTOP in preliminary development of multiple band deconvolution algorithms for modeling radiant area and background temperatures for sub-pixel heat sources, although no funding was requested under this RTOP in FY-91 and FY-92. Data used for this effort included aircraft (NS001) and orbital analog data (AVHRR). Support this year (FY-93) will be required for procurement of a Co-I workstation and future support will be requested for the procurement of a central server machine for the JPL part of IDS Volcanology Team (FY-95 and FY-96).

**W93-70270****428-81-96**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL ASSESSMENT OF ACTIVE VOLCANISM**J. A. Crisp 818-354-9036  
(429-81-96)

One objective is to develop an algorithm for an eruption alarm based on the detection of an SO<sub>2</sub> anomaly by the Moderate-Resolution Imaging Spectrometer (MODIS). Algorithms will also be developed for estimating SO<sub>2</sub> concentrations in volcanic plumes, using data from MODIS and Atmospheric Infrared Sounder (AIRS). Another objective is to provide input to the TES and MLS teams for volcanology study requirements (maps of SO<sub>2</sub>, HCl, and HF concentration) and to prepare for the analysis of the data that will be provided by these teams by studying pre-EOS analog datasets. The ultimate objectives for the EOS execution phase will be to produce global maps showing the distribution and timing of SO<sub>2</sub> alarms and the size of SO<sub>2</sub> anomalies. Assessments will be made of the annual contribution of volcanoes to the global budget of SO<sub>2</sub> and the related climate effect. The EOS data will also be used to study the relationship between magmatic activity and fluctuations in SO<sub>2</sub> emissions and the ratio SO<sub>2</sub>/HCl, which are useful in the study of volcanic hazards and magma chamber conditions. SO<sub>2</sub> estimates from MODIS and AIRS data will be compared with aerosol maps produced by other EOS instruments to study the conversion from SO<sub>2</sub> into sulfate aerosols. The SO<sub>2</sub> alarm and measurement algorithms will be developed and tested by running radiative transfer simulations and by studying pre-EOS analog datasets. Continued communication with the TES and MLS teams will be maintained to ensure that we are prepared for analysis of the SO<sub>2</sub> and HCl data that these teams will provide.

**W93-70271****428-81-99**

Goddard Space Flight Center, Greenbelt, MD.

**STUDIES OF VOLCANIC SO<sub>2</sub>**

Arlin J. Krueger 301-286-6358

The objective of this RTOP is to develop an Earth Observing Satellite (EOS) data base of volcanic eruptions derived from TOMS (Total Ozone Mapping Spectrometer) sulfur dioxide analyses. Data sources are the TOMS instruments on Nimbus 7, Meteor-3, Earth Probes, Advanced Earth Observing System (ADEOS), and NOAA satellites and Advanced Very High Resolution Radiometer (AVHRR) and thermal IR sounders on NOAA satellites. The product will be daily files and maps containing the content and spatial distribution of the sulfur dioxide in eruption clouds. This information is potentially useful in volcano-climate studies, volcanology, as material tracers in meteorological studies, and in development of volcanic hazard abatement techniques.

**W93-70272****428-82-06**

Goddard Space Flight Center, Greenbelt, MD.

**OCEAN COLOR DATA SYSTEM**

Robert G. Kirk 301-286-7895

This RTOP covers the part of the NASA in-house program associated with the POP for the Sea-viewing Wide-Field-of-Sensor (SeaWiFS) spaceflight system. It covers the following topics: management costs; data receipt, processing, and distribution; and algorithm and validation programs.

**W93-70273****428-82-11**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AUTOMATED GEOPHYSICAL PROCESSOR DEVELOPMENT FOR THE ALASKA SAR FACILITY**

R. Kwok 818-354-5614

The long-term objective is to develop a geophysical processor system for ice and ocean studies that is capable of automated data processing producing a classification of ice types and an extraction of ice motion parameters from multi-date Synthetic Aperture Radar (SAR) imagery. The goal is to provide data products that can be directly utilized for the analysis of large-scale ice dynamics in the polar regions as well as for practical applications such as navigation and deployment of drilling platforms. As a means to this goal, new data extraction and image processing techniques will be developed under this RTOP and integrated into an operational system for ice information extraction from SAR imagery. This system will be evaluated using Specialized Experimental Applications Satellite (SEASAT) imagery, with the eventual application of the operational system to process ERS-1 (Earth Resources Satellite) data acquired at the Alaska SAR Facility.

(ASF) and data from the Japanese Earth Resources Satellite-1 (J-ERS-1), RADARSAT and the Earth Observation System (EOS) SAR. The approach is to initially develop techniques for ice classification, two-dimensional motion tracking and extraction of ocean wave parameters that are both reliable and efficient. Additionally, as part of this task we will evaluate system architectures that will maximize the autonomy and enhance the performance of the data system. Ice motion tracking is a complex problem due to the translation, rotation and deformation of the different ice types and because of the high spatial-temporal variability of sea ice. These characteristics mandate the development of new image processing approaches to the classification and tracking problems. The primary tasks include: development of contextual classification techniques for categorization of sea ice; development of feature tracking techniques for identification of image sequences; reasoning methodologies for utilization of spatial constraints and motion predicts from ice dynamics models; extraction of ocean wave parameters from high resolution image spectra; and evaluation and testing of system architectures that are optimal to the implementation of such a system. These capabilities will be initially developed for E-ERS-1 and then modified for the J-ERS-1 and RADARSAT data sets.

**W93-70274****428-82-18**

Goddard Space Flight Center, Greenbelt, MD.

**REMOTE MEASUREMENT OF THE GAIN OF SATELLITE RADIOMETERS: THE NASA AIRCRAFT SATELLITE INSTRUMENT CALIBRATION (NASIC) PROJECT**

Peter Abel 301-286-6829

The objectives are to determine the radiometric gains of satellite radiometers observing the Earth at visible and near-infrared wavelengths, using a calibrated spectroradiometer on board a high flying aircraft as a radiometric calibration transfer standard; calibrate Advanced Very High Resolution Spectrometer (AVHRR), Visible Infrared Spin Scan Radiometer (VISSR)/Atmospheric Sounder (VAS), and GOES Imager at least three times a year; provide results to interested user groups, and in particular to the International Satellite Cloud Climatology Project (ISCCP) and the AVHRR Pathfinder Project; and improve the method, equipment and software to establish a rapid response and data analysis capability to underly the Moderate-Resolution Imaging Spectrometer (MODIS) and other Earth Observing System (EOS) radiometers. The approach is based on the National Institute of Standards and Technology (NIST) traceable aperture radiometric standards maintained at the Goddard Space Flight Center (GSFC). These standards must be recalibrated on a monthly basis with reference to standard lamps and/or standard detectors to maintain required absolute accuracy. The aircraft spectroradiometer is calibrated at GSFC before and after a flight. All flights will be on a NASA ER2. White Sands, NM, has been used in the past as the target for calibration transfer. Future targets will include brighter targets (clouds) to calibrate larger dynamic ranges, spectrally diverse targets (forests) to investigate spectral shifts, and low radiance targets (oceans) to calibrate ocean-specific sensors and low radiance applications of AVHRR data.

## EOS Science

**W93-70275****429-81-04**

Goddard Space Flight Center, Greenbelt, MD.

**4D DATA ASSIMILATION FOR EOS**

Richard B. Rood 301-286-8203

The objective was to develop a data assimilation system for the Earth's atmosphere, ocean, and land surface. This system is to produce research quality data sets for process studies and global change studies. Atmospheric assimilated data sets will be

produced for El Nino time scales. These data sets will be used to address problems of atmospheric transport, interannual variability, and moist processes. These applications will guide the development of new model and analysis algorithms to improve the quality of the data sets. Future applications will address oceanic and land surface problems.

**W93-70276****429-81-06**

Goddard Inst. for Space Studies, New York, NY.

**INTERANNUAL VARIABILITY OF GLOBAL CYCLES**

James E. Hansen 212-678-5619

(428-81-06)

Our objective is to investigate the interannual variability of key global parameters and processes in the global carbon, energy and water cycles. Specifically, our investigation will develop, analyze, and make available global geophysical data sets derived from pre-EOS and EOS (Earth Observing System) observations in combination with models. Our strategy is to focus on analysis of interannual variability in data sets; this should yield information on key earth science processes, without the requirement of waiting until long-term trends are apparent. Such attempts to use pre-EOS and EOS data as soon as possible will be crucial to refined definition of EOS observing and data systems.

**W93-70277****429-81-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ROLE OF AIR-SEA EXCHANGES AND OCEAN CIRCULATION (SCIENCE)**

W. T. Liu 818-354-2394

(428-81-10)

This is an interdisciplinary science investigation of NASA's Earth Observing System (EOS) Program. The objective is to study the role of ocean circulation and the ocean-atmosphere exchanges in affecting global climate changes. Methods to compute ocean surface heat, momentum, and water fluxes using satellite data are being developed and improved. The responses of the atmosphere and ocean to these surface forcings, as related to the storage and transport of heat and greenhouse gases, will be examined. Tropical ocean-atmosphere interaction will be studied first. The energy and hydrologic balances of the coupled ocean-atmosphere system will be examined. An eddy-resolving general circulation model to assimilate satellite data and to provide a realistic four-dimensional description of ocean circulation will be developed. We will extend and join our funded studies in satellite missions such as Earth Resources Satellite (ERS-1), NASA Scatterometer (NSCAT), Topology Ocean Experiment/Poseidon (Topex/Poseidon), and Tropical Rain Measuring Mission (TRMM). We will utilize our established participation and leadership in the field campaigns, the monitoring programs, and the modeling efforts of TOGA (Tropical Ocean and Global Atmosphere) and WOCE (World Ocean Circulation Experiment). We will draw upon operational satellite data and will follow closely the development of data systems such as ISCCP (International Cloud Climatology Project), Wetnet, GPCP (Global Precipitation Climatology Project), and SRB (Surface Radiation Budget) Project. We will contribute to the Global Energy and Water Cycle Experiment (GEWEX) as soon as it is ready to address problems over the ocean. These studies will pave the way for the era of EOS platforms.

**W93-70278****429-81-16**

Goddard Space Flight Center, Greenbelt, MD.

**GLOBAL HYDROLOGIC CYCLE**

William K.-M. Lau 301-286-7208

(428-81-16)

The objectives of this RTOP are to improve our understanding in the following areas: the physical mechanisms of atmospheric hydrologic processes; the role of hydrologic processes in large scale ocean-atmosphere-land interaction leading to natural fluctuation of the global climate system over a variety of time scales; and the role of land surface processes, including storage, in the global hydrologic cycle, with emphasis on the interaction and integration of regional to global scales. The approach will be to make extensive use of data collected from existing satellite

missions and from EOS; to use results obtained for the pre-EOS phase to provide guidance for instrument design in the launch phase and to further our understanding of global hydrologic processes through model development and data analysis; and to emphasize a synergistic approach based on analysis of data from space and non-space platforms as well as modeling.

**W93-70279**

**429-81-26**

Goddard Space Flight Center, Greenbelt, MD.

**BIOSPHERE ATMOSPHERIC INTERACTIONS**

Piers J. Sellers 301-286-4173

A global atmosphere general circulation model will be forced with surface data sets derived from Advanced Very High Resolution Radiometer (AVHRR) data to calculate surface-atmosphere fluxes of energy, heat, water, and CO<sub>2</sub>. Regional ecology models will be developed.

**W93-70280**

**429-81-36**

Goddard Space Flight Center, Greenbelt, MD.

**EOS IDS, STRATOSPHERIC TEMPERATURE AND TRACE GAS TRENDS**

Mark R. Schoeberl 301-286-5819

The investigation is a two-component effort to characterize both the short- and long-term stratospheric changes which have occurred and will occur over the period beginning with Nimbus 7 observations in late 1978, continuing with Upper Atmosphere Research Satellite (UARS) and on through the Earth Observing System (EOS) observing period. The first part of this proposal involves the generation of climatological data sets for ozone, temperature and trace gases (N<sub>2</sub>O, CH<sub>4</sub>, NO<sub>2</sub>, NO, etc.). These data sets will be made available to the Earth Observing System Data Information System (EOSDIS) during definition phase for use by other interdisciplinary and instrument investigators. The second part of the investigation is to study natural and anthropogenic changes in the stratosphere as revealed by the climatological data sets. In particular, we are interested in being able to separate natural and anthropogenic processes in order to better assess the exact magnitude of anthropogenic changes and understand the natural chemical/dynamical/radiative interaction and feedback processes within the stratosphere. We propose to use the data assimilation model and other 2- and 3-D models to facilitate the generation of the climatological data sets mentioned above as well as undertake the theoretical investigations.

**W93-70281**

**429-81-38**

Langley Research Center, Hampton, VA.

**EOS SCIENCE**

W. R. Hook 804-864-6055

The objective of this RTOP is to improve understanding of atmospheric processes which influence global change and thereby contribute to the interdisciplinary Earth Science investigations being carried out as a part of the Earth Observing System (EOS) Program. Specific tasks include: (1) studies of the role of clouds in the Earth's radiant energy budget; and (2) observational and modeling studies of radiative, chemical, and dynamical interactions in the Earth's atmosphere.

**W93-70282**

**429-81-64**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**POLAR EXCHANGE AT THE SEA SURFACE: JPL COMPONENT**

F. D. Carsey 818-354-8163

This RTOP covers the JPL work as part of the POLES Earth Observing System (EOS) Interdisciplinary Project. Our work research will concentrate on the generation of algorithms for sea ice geophysical fluxes from satellite data with a focus on scientifically significant ice-margin regions, at present the Weddell and Greenland Seas. The objective of this work is the accurate, routine estimation of heat, brine and momentum fluxes from these polar seas. The basic approach is the merging of data from Special Sensor Microwave/Imager (SSM/I) and Synthetic Aperture Radar (SAR) and other data available. Specifically we plan in 1993 to: (1) continue studies using SAR and SSM/I data in studies of

algorithms to generate the surface heat and brine fluxes of the Greenland Sea; (2) begin this process for the Weddell Sea; and (3) examine the consequences of errors and general data characteristics of the SAR ice motion and SSM/I data streams. It will be necessary to initiate geophysical flux estimation production through the latter part of the decade, including particularly the flight phase of RADARSAT and EOS. Our approach is to use SAR data to track the ice and estimate opening and closing while using SSM/I data and weather analyses to estimate thickness changes with time. A key element of the flux analysis is the use of ice motion data in the conversion of SSM/I Tb's to ice thickness changes; we have modeled the expected changes in Tb in both the East Greenland Current and the Odden region, and next we will check the sensitivity of this calculation to errors and gaps in the ice motion field as generated on the SAR schedule of 1 to 2 velocity determinations per week. The ice-motion gaps arise in two ways; some ice is simply missed by the limited sampling procedure of the narrow-swath SAR (or the cloud-limited Advanced Very High Resolution Radiometer (AVHRR)), and some ice motion data are missed if the changes in the ice cover between SAR observations are great enough. At present the specific robustness of the ice motion analysis to ice cover changes has not been assessed. Finally the accuracy of ice motion to predict actual opening and closing has not been tested. This testing will be part of the Global Positioning System (GPS) validation performed under the Alaska SAR Facility-NASA Radar Altimeter (ASF-NRA). There is a critical need for analyses of the sort discussed here. For the 1988 data analysis we used ice motion data from AVHRR generated by the Danish scientists in the Greenland Sea Project; we plan to use Earth Resources Satellite (ERS-1) SAR-derived data for the winters of 1992 and 1994, and possibly 1993.

**W93-70283**

**429-81-72**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**PROJECT TO INTERFACE MODELING**

R. W. Zurek 818-354-3725

(428-81-72)

The unique observational capabilities provided by the Earth Observing System (EOS) program have the potential for driving major improvements in climate models at the global and regional scale. The National Center for Atmospheric Research (NCAR) EOS Project to Interface Climate Modeling on Global and Regional Scales with EOS Observations is a selected interdisciplinary investigation designed to work synergistically between the selected EOS measurement capabilities, detailed research on the physical mechanisms of climate change, and the development of global climate and global change models. The emphasis is on surface and atmospheric processes related to the hydrological cycle and atmospheric transport. In parallel with the NCAR climate modeling program, the project will focus on the sensitivity of climate models to EOS observations, the framework for the assimilation of EOS data needed for climate models, the application of EOS data sets to model validation and as model boundary conditions, and development of climate model parameterizations and diagnostics that are more compatible with remotely sensed (satellite) data than those at present. The project will also carry out prototype applications of currently available data sets to improve our framework for relating EOS data to climate models. New approaches to the analysis of satellite data will be developed, as applicable to the EOS sensors and to the validation of model simulations. This includes new and modified approaches to archiving and visualization of global satellite data and model simulations, as needed. Specific JPL research tasks include: (1) provision, analysis, and documentation of prototype data sets; (2) determination of the sensitivity of EOS observing systems to model-required or model-generated fields; (3) development, refinement and application of interactive software tools for the analysis and display of satellite remote sensing data and for the comparison of such data with climate model simulations.

**W93-70284****429-81-80**

Goddard Space Flight Center, Greenbelt, MD.

**IDS SCIENCE FOR WHOI/GSFC EOS PROJECT:****BIOGEOCHEMICAL FLUXES AT THE AIR-SEA INTERFACE**

Anne M. Thompson 301-286-2629

(429-81-36; 429-81-99)

Objective 1 is to compute sea-to-air fluxes of the photochemically reactive gases Dimethyl Sulfide (DMS) and CO using ocean color, UV and lower atmosphere dynamic data. Objective 2 is to calculate boundary layer concentrations of DMS, CO, and SO<sub>2</sub> and related trace constituents. Monthly mean maps are to be produced. Objective 2 is to be achieved in parallel with similar research for Schoeberl/Strat. For flux computation, pre-launch data sets will include Coastal Zone Color Scanner (CZCS) (and Sea-WIFS (Wide Field Instrument), if launched). Eos data needed are ocean color from the Moderate Resolution Imaging Spectrometer (MODIS), surface temperature and winds from STIKSCAT, the Advanced Microwave Sounding Unit (AMSU), and the Laser Atmospheric Wind Sounder (LAWS). Photochemical calculation will use N x 1-D computations with the GSFC 1-D tropospheric photochemistry model using MOPPITT/TRACER CO, O<sub>3</sub> (from Eos-A, e.g., HRDLS; from Eos-B, TES), and other data to constrain tropospheric OH. Pre Eos data sources will be obtained from TOMS, and marine boundary layer trace gas and meteorological data from cruises (e.g., SAGA 3, 1990; MAGE and ASTEX/MAGE, 1992; dedicated WHOI/Eos cruise - 1993 or 1994) appropriate for model validation and construction of data sets for EosDIS.

**W93-70285****429-81-94**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL ASSESSMENT OF ACTIVE VOLCANISM**

D. C. Pieri 818-354-6299

(428-81-94)

Support is requested in this RTOP for science activities to be carried out under sponsorship of the Earth Observing System (Eos) Volcanology Interdisciplinary Science Team. Science activities here are related to science algorithm development as outlined in the revised Volcanology IDS Proposal entitled, 'A Global Assessment of Active Volcanism, Volcanic Hazards, and Volcanic Inputs to the Atmosphere from the Earth Observing System'. Work under this RTOP is directed toward the remote sensing of the thermal properties of active volcanoes during eruptions as well as during quiescent baseline periods. Specific activities in the thermal area to be carried out under this RTOP are: (1) remote detection of volcanic eruptions by thermal anomaly recognition; (2) remote determination of surface temperature distributions of active lava flows; and (3) determination of long term thermal energy budgets for active volcanoes. During the operational phase of Eos, these observations will be carried out using the near-, mid-, and thermal-IR bands of Moderate Resolution Imaging Spectrometer-Nadir (MODIS-N) and Advanced Very High Resolution Radiometer (ASTER) instruments. Part of the algorithm development for (1) will involve the creation of an alarm system that will scan incoming MODIS-N data daily to alert team members of anomalously high thermal spikes over volcanic areas. The monitoring of actively flowing lavas in (2) will require systematic data acquisitions with the ASTER instrument (or High Resolution Imaging Spectrometer (HIRIS) when available) throughout available IR bands. Determination of thermal budgets in (3) will require the development of long term IR data bases over relevant active volcanoes to monitor pre-, syn-, and post-eruption thermal fluxes. Prelaunch activities involve development of analog data sets using Advanced Very High Resolution Radiometer (AVHRR) and airborne data over active volcanoes.

**W93-70286****429-81-95**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL ASSESSMENT OF ACTIVE VOLCANISM**

H. A. Zebker 818-354-8780

(428-81-95)

This RTOP, in conjunction with the related RTOP 428-81-95, is part of the Earth Observing System (Eos) Interdisciplinary Science

proposal, 'Global Assessment of Active Volcanism', headed by Dr. Peter Mouginis-Mark of the University of Hawaii. Our role in this overall study is to develop the means to map active volcanoes topographically using interferometric Synthetic Aperture Radar (SAR) data acquired by the Eos SAR, ESA Remote Sensing Satellite-1 (ERS-1), RADARSAT, and any other available orbital SAR's. The orbital SAR's will provide data from which we may derive topographic maps of 10 m height accuracy over images tens of kilometers in extent at a spatial resolution of 20 to 30 m. It may also be possible to generate topographic change maps, on a relative rather than absolute scale, sensitive to cm scale changes in height that may serve as precursors to eruptive events. Topographic measurements before and after volcanic events will permit estimation of displaced volumes of material following explosive activity, which are extremely important in the estimation of the atmospheric effects of Alaskan eruptions and their influence on climate. Local climate conditions are also effected by the interaction of lava flows on frozen ground and ice sheets. While not explicitly part of this investigation, an understanding of the latter effect would be of major importance in hazard assessment in regions such as Iceland where melting of ice during an eruption is significant. These measurements derived from radar data are especially applicable in the study of active volcanism, where conventional monitoring using optical sensors or in situ measurements are either infeasible due to atmospheric obstruction at optical wavelengths or too dangerous for manned exploration. However, such monitoring is necessary both for hazard assessment of active eruptions and for understanding the past history and long-term effects of the eruptions on local, and in extreme cases, global climate.

**W93-70287****429-81-96**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL ASSESSMENT OF ACTIVE VOLCANISM**

J. A. Crisp 818-354-9036

(428-81-96)

One objective is to develop an algorithm for an eruption alarm based on the detection of an SO<sub>2</sub> anomaly by the Moderate-Resolution Imaging Spectrometer (MODIS). Algorithms will also be developed for estimating SO<sub>2</sub> concentrations in volcanic plumes, using data from MODIS and Atmospheric Infrared Sounder (AIRS). Another objective is to provide input to the TES and MLS teams for volcanology study requirements (maps of SO<sub>2</sub>, HCl, and HF concentration) and to prepare for the analysis of the data that will be provided by these teams by studying pre-Eos (Earth Observing System) analog datasets. The ultimate objectives for the Eos execution phase will be to produce global maps showing the distribution and timing of SO<sub>2</sub> alarms and the size of SO<sub>2</sub> anomalies. Assessments will be made of the annual contribution of volcanoes to the global budget of SO<sub>2</sub> and the related climate effect. The Eos data will also be used to study the relationship between magmatic activity and fluctuations in SO<sub>2</sub> emissions and the ratio SO<sub>2</sub>/HCl, which are useful in the study of volcanic hazards and magma chamber conditions. SO<sub>2</sub> estimates from MODIS and AIRS data will be compared with aerosol maps produced by other Eos instruments to study the conversion from SO<sub>2</sub> into sulfate aerosols. The SO<sub>2</sub> alarm and measurement algorithms will be developed and tested by running radiative transfer simulations and by studying pre-Eos analog datasets. Continued communication with the TES and MLS teams will be maintained to ensure that we are prepared for analysis of the SO<sub>2</sub> and HCl data that these teams will provide.

**W93-70288****429-81-97**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL ASSESSMENT OF ACTIVE VOLCANISM**

A. B. Kahle 818-354-7265

(465-44-02)

The overall objective, as an accepted team member, is to participate in the Earth Observing System (Eos) Interdisciplinary Science Study entitled, 'A Global Assessment of Active Volcanism, Volcanic Hazards, and Volcanic Inputs to the Atmosphere from the Earth Observing System'. In the coming year algorithm

development will continue. Those algorithms for which I have the prime responsibility include No. 18-Low Temperature Volcanic Thermal Anomalies, and No. 21-Atmospheric Profiles. Others, to which I will also contribute, include No. 1-Eruption Detection by Thermal Spike, No. 4-Eruption Plume Temperature, No. 15-Temporal Change in Volcano Morphology, No. 16-Lava Flow Temperature Distribution, and No. 23-Supplemental Data Sets. The algorithm development work is partially supported under RTOP 465-44-02 (Evolution of Volcanic Terrains).

**W93-70289****429-81-99**

Goddard Space Flight Center, Greenbelt, MD.

**STUDIES OF VOLCANIC SO<sub>2</sub> THEORY**

Arlin J. Krueger 301-286-6358

The objective of this RTOP is to develop algorithms for retrieval of sulfur dioxide column amounts from UV radiances measured with Total Ozone Mapping Spectrometer (TOMS) instruments, and for assessment of associated parameters, such as plume height and velocity. Data sources are the TOMS instruments on Nimbus 7, Meteor-3, Earth Probes, Advanced Earth Observing System (ADEOS) and NOAA satellites, and Advanced Very High Resolution Radiometer (AVHRR) and thermal IR sounders on NOAA satellites. This information is potentially useful in volcano-climate studies, volcanology, and as material tracers in meteorological studies.

**W93-70290****429-97-04**

Goddard Space Flight Center, Greenbelt, MD.

**FOREIGN VISITOR SUPPORT**Compton J. Tucker 301-286-7122  
(462-41-82)

The objective is cooperative Brazilian-U.S. satellite remote sensing research on the Amazon Basin of Brazil. This RTOP will support a Brazilian scientist at NASA/Goddard for this cooperation. Landsat Thematic Mapper (TM) and NOAA Advanced Very High Resolution Radiometer (AVHRR) data will be cooperatively analyzed to study tropical forests, tropical savannas, investigate techniques for assessing tropical deforestation, identify and monitor tropical forest and savanna fires, and relate these topics to the carbon cycle within the Amazon Basin of South America.

## Space Physics Theory

**W93-70291****431-06-00**

Goddard Space Flight Center, Greenbelt, MD.

**SPACE PHYSICS THEORY PROGRAM**

T. J. Birmingham 301-286-7110

The subject RTOP supports a program of theoretical analysis and computer modeling carried out by 17 autonomous groups in the university, industrial, and government communities to whom funds are distributed via grants, contracts, and transfers. The Space Physics Theory Program (SPTP) has been in continuous existence since FY-79, but it has only been managed as a GSFC project since FY-91. Fund recipients are selected by the NASA NRA process which takes place every three years. A solicitation, evaluation, and selection will take place in the summer of 1992 and will serve as the basis for FY-93 funding. In FY-92, 17 groups were supported (cf. 1471A). A majority are expected to re-propose, but there is expected to be turnover.

## Space Physics SR&T

**W93-70292****432-20-00**

Goddard Space Flight Center, Greenbelt, MD.

### **SOLAR WIND-MAGNETOSPHERE-IONOSPHERE COUPLING, MAGNETIC FIELD MODELING, AND MAGNETOTAIL DYNAMICS**

James A. Slavin 301-286-5839

This research effort consists of seven distinct tasks directed at furthering our knowledge and understanding of the global solar wind-magnetosphere-ionosphere coupled system. Task 1 (P.I.- A. Klimas) investigates solar wind-magnetosphere coupling through the use of recently developed predictive filtering and nonlinear chaos modeling techniques. Task 2 (P.I.- J. Slavin) examines the structure and dynamics of the earth's magnetotail through a balanced mixture of theoretical and data analysis modeling studies. Task 3 (P.I.- M. Smith) investigates the processes by which solar wind plasma enters the magnetosphere and penetrates to low altitude. Task 4 (P.I.- D. Stern) consists of theoretical modeling studies directed toward the investigation and representation of the major magnetospheric current systems and the magnetic fields they generate. Taken together, these investigations offer a well balanced GSFC/Lab for Extraterrestrial Physics (LEP) Research Program addressing most key aspects of solar wind-magnetosphere-ionosphere coupling.

**W93-70293****432-36-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MAGNETOSPHERIC COUPLING**

R. Goldstein 818-354-0241

This RTOP consists of two subtasks: (1) Cometary Plasma Physics using Data from the Giotto Ion Mass Spectrometer which include analysis of Giotto/Halley comet plasma data for wave processes and energy transport; and (2) Jovian Magnetospheric Processes which include analysis of time variability of Jovian decimetric (synchrotron) radiation with ground-based radio telescope observations, and comparison of results with theoretical models.

**W93-70294****432-48-00**

Goddard Space Flight Center, Greenbelt, MD.

**THERMOSPHERE-IONOSPHERE-MESOSPHERE-MAGNETOSPHERE INTERACTIONS**

R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the ionosphere, mesosphere, thermosphere, exosphere and inner magnetosphere, and to identify and understand the physical and chemical processes operating in these regimes, emphasizing how they interact. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the study of long-term phenomena, comparison of data with new theories and models, correlative studies of data obtained from various satellites and ground based observatories, and the deposition of additional data in the National Space Science Data Center. The essential data to be used in this investigation include electron densities and temperatures, ion and neutral composition, neutral winds, ion temperatures and drifts, electric fields, magnetic fields, electromagnetic radiation and energetic particles of magnetospheric and ionospheric origin. These data are used to determine the various interrelated chemical, compositional, dynamical, and energetic states of the ionosphere, exosphere, thermosphere and mesosphere and the transport and deposition of mass, momentum and energy in and between these physical regions. These basic properties and processes are then used to analyze specific geophysical phenomena such as atmospheric escape, electric field induced ion drifts in the ionosphere, chemistry and dynamics of mid and high latitude troughs, auroral substorms, ionospheric storms, Joule heating, polar cap absorption (PCA) events, tidal and gravity waves, depletion and filling of plasmasphere, ionospheric electrodynamic processes, equatorial 'bubble' formation, stable auroral red (SAR) Arcs, etc.

## Space Physics ATD

**W93-70295**

**433-04-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### INTERDISCIPLINARY ATD STUDIES

C. L. Yen 818-354-4899

The objective of this RTOP is to generate innovative approaches to conduct space physics missions. The study leader shall coordinate with the space physics science community, Code-SS advanced studies office, and JPL management to set priorities on a set of studies potentially beneficial to Code-SS. Potential categories of studies are: (1) applications of simplified mission design and light weight spacecraft concepts to achieve low cost; and applications of advanced or new technologies on problematic elements of various missions.

**W93-70296**

**433-06-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### SOLAR PROBE ATD

J. E. Randolph 818-354-2732

The objectives of this RTOP are to develop required material properties for high temperature shield material candidate, to support spacecraft system development using Lite-Sat technology, and develop cost estimates for both the spacecraft and thermal shield. This will be accomplished by conducting high temperature carbon-carbon material testing utilizing as a baseline the JPL developed heat shield configuration. The tests required are: (1) directional, spectral emittance and normal, total emittance at temperature levels of 1000 to 2400 K for carbon-carbon sheets in both as manufactured and roughened conditions; and (2) thermal conductivity of carbon-carbon sheets and the sandwich structure (for the IR shield), at temperatures between 1400 and 2400 K. FY-93 test data will be analyzed and a written report of the test data and analytical effort will be provided. System spacecraft studies will be conducted with industry support (RFI) to address developing concepts that will be supported by the Lite-Sat technology. Using this technology initial cost estimates for the spacecraft development and fabrication will be developed. Support from industry (RFI) will be requested to develop concepts and initial cost estimates for the shield system. This shield concept will be compatible with the Lite-Sat class of spacecraft. The approach is to develop high temperature material test data by utilizing industry capability, and request industry to develop cost data for the Solar Probe by using Lite-Sat technology and shield concepts. We will (1) contact industry to develop high temperature material data for shield material; (2) conduct a study to develop spacecraft configuration and initial cost estimates utilizing Lite-Sat technology; and (3) conduct a study to develop shield configuration and initial cost estimate.

**W93-70297**

**433-90-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### SPACE PHYSICS PROGRAM SUPPORT/DETAILEES

R. Goldstein 818-354-0241

Support will be provided to the Space Physics Division, Office of Space Science and Applications, NASA Headquarters, by the assignment of detailees, in addition to the continuation of requested studies, participation in project/program reviews, and other activities as directed.

## Space Physics Sounding Rocket Research

**W93-70298**

**435-11-00**

Goddard Space Flight Center, Greenbelt, MD.

## SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS

R. F. Pfaff 301-286-6328

The objective is to perform measurements and experiments that will lead to an understanding of the interactive processes that occur between neutral gases, plasmas, energetic particles, electric fields and electromagnetic waves in the atmosphere, ionosphere, and near-Earth magnetosphere. Emphasis is placed on measurements and experiments that utilize the unique characteristics of sounding rocket trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Sounding rockets provide the only access for in-situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (30 to 90 km). Historically, this approach has logically been extended to include sounding rocket experiments at remote sites of keen geophysical importance (e.g., the dip equator or the auroral zone); experiments involving sounding rocket flights in association with simultaneous satellite measurements; flight testing of new instrumentation and measurement techniques; and investigations of the electrodynamics of middle atmosphere (i.e., below 90 km), including experiments that deploy special payloads such as those that descend via parachutes. The individual programs supported by this RTOP have traditionally involved extensive collaborations with other U.S. and European scientific groups and facilities, and international campaigns.

## Spacelab Payload Instrument Development/Astrophysics

**W93-70299**

**440-62-59**

Goddard Space Flight Center, Greenbelt, MD.

### HIGH ENERGY ASTROPHYSICS INTERNATIONAL PROGRAMS

J. F. Ormes 301-286-8801

This RTOP provides scientific support and instruments within the Laboratory for High Energy Astrophysics for missions on foreign spacecrafts and other foreign collaborative efforts. As of April 1992, these projects include the Monitoring X-ray Telescope (MOXE) for the Russian Spectrum Roentgen Gamma satellite, ESA's X-ray Multi Mission (XMM), and the Konus instrument being supplied by the USSR for the International Solar Terrestrial Physics (ISTP) Wind spacecraft. MOXE is an all sky monitoring x-ray telescope which is sensitive to transients on a variety of time scales. This instrument will identify interesting sources for the other instruments on board the satellite to observe in more detail with specialized instruments. MOXE is a collaborative effort with Los Alamos National Laboratory. LHEA is providing much of the electronics and the ground support equipment. This RTOP supports the mission scientist for the X-Ray Multi-Mirror Telescope Mission, Dr. Richard Mushotzky. This RTOP also provides for accommodation of the Konus instrument into the ISTP/WIND project, and preparations for the operations and data analysis phase, including collaborative analysis of Konus data with other gamma burst instruments on WIND, Gamma Ray Observatory (GRO), and Mars Observer. Dr. Thomas Cline is the US Instrument Co-principle investigator, and manager. The interface electronics and test support is provided under contract by EER.

**W93-70300**

**440-63-44**

Ames Research Center, Moffett Field, CA.

### THE DEVELOPMENT OF A MID-INFRARED SPECTROMETER FOR THE INFRARED TELESCOPE IN SPACE

T. L. Roellig 415-604-6426

The objective of this RTOP is to develop and construct a



Mid-Infrared Spectrometer (MIRS) for the Infrared Telescope in Space (IRTS). The IRTS is a Japanese telescope that will be launched by a Japanese expendable launch vehicle in 1994. The MIRS is a joint development project between NASA and the University of Tokyo. The spectrometer will have a wavelength coverage ranging from 4.2 to 11.3 microns and will be designed for astronomical studies of diffuse infrared sources. The approach of this RTOP is to divide the technical development between NASA-Ames and the University of Tokyo. The instrument will be assembled at Ames, tested, and then installed in the Japanese spacecraft. The data will be shared equally between NASA-Ames and the University of Tokyo for a proprietary period before release to the general astronomical community.

## Origins of Solar Dynamics

**W93-70301**

**452-11-93**

Ames Research Center, Moffett Field, CA.

### **INFRARED STUDIES OF PLANETARY DEBRIS AROUND YOUNG MAIN SEQUENCE STARS**

F. C. Witteborn 415-604-5520

The objective of this RTOP is a comprehensive search for evidence of planet formation near young main sequence stars, focusing on the infrared signature of collisional debris associated with planetary accretion. Significant infrared excess is expected if as little as 1 percent of the planetary mass remains in an asteroid-micrometeoroid size distribution. Our targets are nearby stars with ages known to lie between 0.01 and 1 Byr, plus older stars for comparison. The main goals of our program are an understanding of the variation of continuum flux excesses and spectral features diagnostic of solid circumstellar grains as a function of stellar age, and a determination of the fraction of young main sequence stars that have such circumstellar grains. The approach of the RTOP is planned observations consisting of broadband infrared photometric surveys of field and cluster stars, combining ground-based data with IRAS data, to be followed by spectroscopy of stars found to have significant thermal infrared excesses. The shape and strength of continuum excesses deduced from the photometry can be used to derive temperature (distance from star) and amount of circumstellar material. The identity and strength of spectral features can be used to characterize the particle composition sizes and collisional history. Planned theoretical work consists of models of grain spectra characteristic of collisionally altered material to be compared with spectra of material around candidate stars, and a rigorous study of stellar age indicators, allowing expansion of the sample of young stars for our observational program to include numerous and nearby field stars.

**W93-70302**

**452-21-93**

Ames Research Center, Moffett Field, CA.

### **PLANET-FORMING DISKS**

P. Cassen 415-604-5597

The objective of this RTOP is to develop a predictive theory of the formation of protostellar disks and their physical and chemical evolution, and to relate these to the history of the primitive solar nebula. The approach used is to generate mathematical models of the physical processes that control interstellar cloud collapse, disk formation and disk dynamical evolution; derive the consequences of the modeled processes for the processing of interstellar material; and test the results by comparison with solar system data derived from the examination of primitive material.

**W93-70303**

**452-22-91**

Ames Research Center, Moffett Field, CA.

### **CONVECTIVE TRANSPORT IN THE SOLAR NEBULA**

J. B. Pollack 415-604-5530

The goal of this RTOP is to calculate directly from the Navier-Stokes equations the local turbulent transport of angular momentum, mass, and heat due to thermal convection under the solar nebula conditions. These results will be used to critique standard phenomenological models, to test the ability of convection to sustain itself through viscous heat release, and to develop better models as necessary. The global evolution of the solar nebula disk will be calculated from these models to determine its evolutionary timescale and structure due to turbulent convection. These results will be compared with recent observations of low-mass pre-main-sequence stars. More accurate predictions of grain coagulation rates will also be possible with the small-scale turbulence statistics. Our approach is the use of hydrodynamic simulations of turbulent convective flow on NASA-Ames Cray supercomputers. The governing fluid equations are solved exactly for low Reynolds number flows, and flow statistics (space and time averages) are accumulated for statistically steady flows. These statistics provide direct determination of heat fluxes and Reynolds stresses, responsible for heat and angular momentum transport, and provide the basis for modeling such terms. High Reynolds number flows require large eddy simulation, in which the effect of the small scales is modeled. We will test the performance of subgrid-scale models for flow conditions relevant to the solar nebula and use successful models in large eddy simulations.

**W93-70304**

**452-22-93**

Ames Research Center, Moffett Field, CA.

### **TWO-PHASE NEBULAE**

J. Cuzzi 415-604-6343

(151-01-60; 151-01-08)

The objective of this RTOP is to contribute to the understanding of the origin of the planets of the solar system, one of NASA's most fundamental goals. Research is focused on modeling the accretion of particulates in the size range sampled by meteorites (microns to meters in particle radius) within a turbulent layer near the nebula midplane in which the dynamical influence of the particle and gas phases on each other is substantial, leading to a strongly coupled behavior of the system as a whole. The results obtained are of both immediate and long-term value to NASA in guiding extraterrestrial sample analysis (meteorites, interplanetary dust particles (IDP's), Mars samples, comet nucleus samples) and astrophysical observations of extrasolar particle disks (Hubble Space Telescope (HST), Stratospheric Observatory for Infrared Astronomy (SOFIA), Space Infrared Telescope Facility (SIRTF)). The approach of this RTOP is to use theoretical modeling of the two-phase fluid dynamics of the particle-gas system to provide mean and turbulent flow states in which to implement particle coagulation calculations. Our coagulation calculations will incorporate theoretical studies of grain sticking for a variety of particle compositions (water, silicate, organic) and configurations (solid, fractal, and composite). Coagulation determines the evolution of the particle size distribution which will feed back into the fluid dynamics to influence the generation and damping of mean flows and turbulence. Ultimately radiative transfer, energetics, and simple chemical mixing will be incorporated in a self-consistent fashion.

**W93-70305**

**452-23-94**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **ORIGINS OF SOLAR SYSTEMS**

J. D. Goguen 818-354-8748

This group of research tasks addresses a range of modeling and simulation problems concerning the origins of solar systems. Specifically, characteristic features of the planetary accretion process are investigated, including density wave propagation during disk-planet interactions and a search for features that distinguish circumstellar disks containing protoplanetary objects. Models are developed for the dynamics of cometary Oort clouds around field stars orbiting the galaxy within a realistic, changing dynamical environment. This study will elucidate possible structures for these comet clouds and, consequently, their detectability, with possible inferences for the existence of unresolved planets closer to the central star. Chemical models will be examined for the dense star-forming fragments of interstellar gas and dust clouds. The



physical and chemical conditions of such regions may help to explain the observed chemical abundances in our solar system and the origin of comets. The approach makes use of theoretical models of density wave disturbances in the study of planetary accretion processes, including a study of resonant trapping of planetesimals. Cometary Oort cloud perturbations are modeled using a computer-based simulation of the galactic dynamical environment. Finally, the approach includes the use of computer code of time-dependent interstellar ion-molecule chemistry.

**W93-70306****452-33-93**

Ames Research Center, Moffett Field, CA.

**CHEMICAL EVOLUTION OF INTERSTELLAR ICES: THE CONNECTION WITH PRIMITIVE SOLAR SYSTEM MATERIALS**

L. J. Allamandola 415-604-6890

The objective of this RTOP is to increase our knowledge of chemical evolution and deuterium fractionation in interstellar ices and comets. These processes determine the raw material from which the solar system formed and are the link between organic matter in the solar system, comets, and meteorites. The approach of the RTOP is to prepare interstellar ice analogs and complex organic molecules in the laboratory under conditions simulating those in space. Their spectroscopic properties will be studied as part of the analysis of the materials produced by energetic processing. These materials will also be analyzed chemically to determine which specific compounds are made. Transmission electron micrography will be made of the ices to determine the microscopic structures of the ice in order to understand how these structures mediate macroscopic behavior including gas release from comets.

**W93-70307****452-89-91**

Goddard Space Flight Center, Greenbelt, MD.

**MANAGEMENT SUPPORT: ORIGINS OF SOLAR SYSTEMS RESEARCH PROGRAM**

J. Nuth 301-286-9467

The purpose of this RTOP is to support the requirements of the Discipline Scientist for the Origins of Solar Systems Research Program at Goddard Space Flight Center (GSFC). NASA Headquarters provides the funds necessary to support the operations of the NASA Origins of Solar Systems Research Program Discipline Scientist at GSFC. Specifically, this provides money for support of a part-time scientific typist and data entry technician to prepare the procurement paperwork necessary to initiate NASA funding (through NASA Headquarters) for researchers selected through the Origins of Solar Systems NRA. This contractor provides up-to-date accounting information to the Discipline Scientist and types all correspondence and reports from the Discipline Scientist to both NASA Headquarters and the scientific community. This RTOP also provides the funds necessary to hire a part-time laboratory technician who handles some of the more routine laboratory experiments and equipment maintenance for the Discipline Scientist in recognition of the time spent by the Discipline Scientist in the day-to-day management of the Origins of Solar Systems Research Program for NASA Headquarters.

## Radiation and Dynamic Processes

**W93-70308****460-20-00**

Marshall Space Flight Center, Huntsville, AL.

**PROCESS STUDIES: RADIATION DYNAMICS AND HYDROLOGY, RADIATION AND DYNAMIC PROCESSES**

R. J. Koczor 205-544-3078

The objective is to perform a series of studies to assess current remote sensing capabilities to study earth processes, develop aircraft-based prototype instruments to test future remote sensing concepts, and derive relevant geophysical parameters from these

aircraft and space-based sensors which contribute to describing the radiational and dynamical processes associated with the earth system. The approaches are to utilize the talents of university and private contractor groups to assist in-house engineers in the development of aircraft remote sensing systems, utilize in-house expertise to assess these measurements, and derive the necessary geophysical parameters to describe the earth system.

**W93-70309****460-21-00**

Ames Research Center, Moffett Field, CA.

**CO2 LIDAR BACKSCATTER EXPERIMENT**

R. F. Pueschel 415-604-5254

The objective is to measure aerosol size distributions and particle shapes and composition simultaneously with the CO2 lidar measurements as a means of validating the lidars which will be precursors to the Doppler lidars planned for wind measurements from space (LAWS - Laser Atmospheric Wind Sounder). The approach is to fly impactors and laser aerosol spectrometers on the Ames DC-8 aircraft to measure the global variability in aerosol size distributions and particle characteristics. These measurements will contribute data needed for lidar backscatter calculations to assess the sensitivity of CO2 lidar for wind velocity measurements. Emphasis in FY-93 will be a final analysis and publication of data collected in GLOBE I and II mission flights.

**W93-70310****460-21-28**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**IR REMOTE SENSING OF SST**

D. E. Hagan 818-354-7073

The objectives of the proposed work are to investigate and improve infrared methods of measuring sea surface temperatures (SST) from space, and to improve basic understanding of ocean boundary layer radiation and thermodynamic processes. The proposed measurements will determine the extent to which changes in SST modify the boundary layer radiation profile under high water vapor conditions, and will verify radiative transfer analyses which show the relationship between the atmospheric water vapor, air temperature, the ocean surface radiance, and boundary layer aerosol in the 10 to 12 micron region used for remote sensing purposes. As a second component of the research plan, the proposed measurements will improve the parameterization of the surface latent heat flux under conditions of low wind speeds and high atmospheric water vapor, and will help determine the extent to which variability in SST determines the scale of atmospheric response. The approach is to obtain aircraft-based, high precision multi-spectral radiometric measurements simultaneously with direct atmospheric flux measurements of heat, moisture and momentum. The radiance measurements will be obtained in several contiguous spectral passbands which cover the atmospheric window region and two spectral bands which closely resemble the spectral channels of present satellite sensors. Boundary layer vertical flux profiles, and measurements obtained over repeated aircraft surface tracks will be obtained under a variety of cloud and water vapor conditions in tropic latitudes as part of the TOGA Coupled Ocean-Atmosphere Response Experiment. The measurements will resolve: the small to mesoscale part of the SST structure; the small-scale variability of the temperature difference between the air and SST (an essential part of the heat and moisture fluxes); and the total effect of water vapor on SST measurements from space.

**W93-70311****460-21-52**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AIRBORNE DOPPLER LIDAR**

R. T. Menzies 818-354-3787

(460-22-53; 460-28-41)

The objective of this task is to develop and use an airborne Doppler lidar for measurements of atmospheric wind fields in regions of scientific interest, conducting specialized measurements of atmospheric dynamic processes over critical scales within the boundary layer and free troposphere. It is planned to utilize the Doppler lidar instrument while participating in intensive field observational activities of major atmospheric research programs

planned for the 1990's. The range-gated lidar, coupled with scanning optics, will provide detailed spatial structure of various dynamic processes. This investigation consists of fabrication of an airborne Doppler lidar, in collaboration with groups from NASA Marshall Space Flight Center and National Oceanic and Atmospheric Administration (NOAA) Wave Propagation Laboratory, using a modified version of the existing JPL Airborne Backscatter Lidar (ABL) optics, optical table, and support framework. (NOAA will supply the pulsed laser transmitter, and MSFC will supply the transmit/receive telescope and the Doppler data processing capability.) The instrument will be designed for flights on the NASA DC-8 research aircraft, beginning in FY-95 or FY-96. Instrument integration and system tests will be performed at JPL. A hard target calibration procedure will be used to permit both ground-based and airborne measurements of atmospheric backscatter coefficients in addition to wind field measurements. The backscatter data obtained will be of value in the continuing study of atmospheric aerosol and cloud backscatter characteristics at infrared wavelengths.

**W93-70312****460-22-52**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**LIDAR TARGET CALIBRATION FACILITY**

R. T. Menzies 818-354-3787

(460-22-53; 460-28-41)

The primary objective of the JPL Lidar Target Calibration Facility is to provide accurate and consistent calibration of CO<sub>2</sub> lidar targets. Customers in the lidar community will each provide a sample to JPL of the target surface which is to be used to calibrate the customer's lidar system. Parameters which are used in the lidar calibration, such as the CO<sub>2</sub> laser wavelength, incident and reflected polarizations, and the polar angle at the target will be specified by the customer. The measurement result provided to the customer for each set of specified parameters will be the target reflectance parameter, which is used in the reduction of hard target and aerosol backscatter data to obtain the desired profile of the aerosol backscatter coefficient. A secondary objective is to measure the depolarization properties and the proximity to Lambertian (diffuse) behavior of customer-supplied and experimental target surfaces. The calibration methodology to be used will strive for maximum measurement continuity and accuracy between an integrating sphere measurement of a Lambertian primary standard, a backscatter reflectance ratio measurement of the customer's target to the primary standard, and the eventual field use of the customer's target to calibrate a lidar system. Accuracy will be achieved through careful experimental techniques such as incorporating spinning targets to reduce special effects. Continuity between the three measurements will include target continuity; illumination continuity - wavelength, polarization, and bandwidth; and geometric continuity - polar angles, solid angles, and target size to beam size relationship.

**W93-70313****460-22-53**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ATMOSPHERIC BACKSCATTER EXPERIMENT**

R. T. Menzies 818-354-3787

(460-22-52; 460-28-41)

The objective of this program is to support studies of the feasibility and scientific value of an Earth-orbiting Doppler lidar for global-scale tropospheric wind measurements, by the direct measurement of tropospheric aerosol and cloud backscatter coefficients at wavelengths in the 9 to 11 micron range over large geographical regions, emphasizing those regions which are important in the global winds measurement studies but difficult to characterize at present due to the scarcity of aerosol measurement data. The use of range-gated lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation consists of flights of an airborne (CO<sub>2</sub>) backscatter lidar (ABL) on the NASA DC-8 research aircraft, configured to measure vertical profiles of aerosol backscatter from the aircraft altitude (near the tropopause) to the surface or above the aircraft altitude. The ABL instrument has been flown on the NASA DC-8 on several missions

over the Pacific Ocean. Southern Hemisphere measurements have also been made. The data obtained are analyzed and considered in the context of related instrument measurements of atmospheric aerosols, cloud cover statistics, and other atmospheric parameters. The data are intercompared with other lidar data in order to model the wavelength dependence of aerosol and cloud backscatter in the infrared. The ABL instrument will be flown in the next few years in its present form, and then it will be converted into a Doppler lidar, whose elements are being developed under a related task (RTOP 460-21-52).

**W93-70314****460-28-41**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**WIND MEASUREMENT ASSESSMENT**

R. T. Menzies 818-354-3787

(460-22-52; 460-22-53)

The objective of this program is to evaluate certain aspects of the Doppler lidar technique for global measurement of tropospheric wind fields. This technique has the potential for providing global wind data from an orbiting platform. Several types of remote measurements of atmospheric wind velocities have been analyzed; e.g., passive microwave, millimeter wave, infrared radiometry, and active visible and infrared range-rated lidar, with the results indicating that the infrared Doppler lidar technique is the superior technique for tropospheric wind field measurements. During FY-93, the work will continue to add to the climatology of aerosol backscatter by further experimental study of vertical profiles of backscatter at CO<sub>2</sub> laser wavelengths in the 9 to 11 micron region. An emphasis will also be placed on assessing the influence of visible and sub-visible cirrus on the backscatter to be expected, including seasonal dependence of probability of occurrence. This study is being conducted using an existing TEA CO<sub>2</sub> lidar facility, employing a single-longitudinal-mode (SLM) injection-controlled TEA laser transmitter and a heterodyne receiver. During FY-93, the development of a solid-state 2-micron lidar will begin, with the objective being the future collection of backscatter profiles at this wavelength as well, to assess seasonal and long-term trend effects. The use of air parcel trajectory analysis capabilities at UCLA will be continued in order to study the dependence of aerosol backscatter on the history of the air parcel. Comparative performance analysis of the major types of Doppler lidar, including both incoherent and coherent detection, have been conducted and reported in the literature. These studies will be re-assessed as new data and new technology become available.

**W93-70315****460-42-00**

Ames Research Center, Moffett Field, CA.

**RADIATIVE EFFECTS IN CLOUDS FIRST INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY REGIONAL EXPERIMENT**

F. P. J. Valero 415-604-5510

The objectives of this work are as follows: (1) to gain an understanding of the interaction of radiation and clouds through the measurement and modeling of the interaction of radiation and clouds - including radiative flux divergence profiles, optical depths, total/diffuse radiation fields, and particle size distributions in stratus and cirrus clouds; (2) to validate satellite-acquired radiative data; (3) to obtain measurements of the absorption of solar radiation by clouds; and (4) to study the structure and radiative properties of marine stratus clouds and their effect on climate. Also, measurements will be made during the Tropical Ocean Global Atmosphere (TOGA)/Coupled Ocean Atmosphere Response Experiment (COARE) experiment using the DC8 and ER2 aircraft. These measurements will include total solar and IR fluxes, brightness temperature, and optical depths. The University of Washington Convair C-131 aircraft will be used during the Atlantic Stratus Experiment (ASTEX) to obtain measurements of the structure and radiative properties of stratocumulus clouds as well as in situ measurements in 'ship tracks' in clouds. The data obtained during this mission will be analyzed to determine the relationship between cloud microstructure and cloud radiative properties. Remote sensing measurements of cloud structure from the NASA ER-2 will be compared with in situ cloud measurements from the Convair C-131.

**W93-70316****460-47-00**

Ames Research Center, Moffett Field, CA.

**MULTIDIMENSIONAL STUDIES OF TROPOSPHERIC CLOUDS**

D. L. Westphal 415-604-3522

The objectives of this work are: (1) to study the atmospheric structure, dynamics, and cloud fields during the First International Satellite Cloud Climatology Project Regional Experiment (FIRE) cirrus field programs; and (2) to develop parameterizations of clouds and their radiative effects for use in mesoscale models and to validate these parameterizations using measurements made during the Cirrus Intensive Field Observation periods. The approach is to couple numerical models of atmospheric dynamics, cirrus cloud microphysics, and radiative heat transfer to form a unique forecast model capable of simulating observed midlatitude weather systems. These model simulations will be compared with observations and will evaluate the ability of the model to simulate the observed cloud fields, radiative fluxes, and the net radiative budget for the domain. Improvements to the model's cloud parameterization will be developed, tested, and validated using data from the Cirrus Intensive Field Observation periods.

**W93-70317****460-97-00**

Ames Research Center, Moffett Field, CA.

**EARTH SCIENCE ADVANCED AIRCRAFT (ESAA)**

P. B. Russell 415-604-5404

(464-14-00)

The objectives are as follows: (1) develop and implement optimal ways of applying NASA skills and facilities (aeronautical and scientific) to the advanced-aircraft needs of the Earth Science community; (2) ensure NASA's continuing leadership role in multi-investigator Earth Science aircraft missions; and (3) interface optimally with Earth Science Advanced Aircraft (ESAA) activities at other agencies and institutions. The approaches include the following: (1) developing documents stating consensus views of the aircraft capabilities needed to answer current and future scientific questions; (2) surveying available and developing technological capabilities; (3) conceiving, advocating, and executing projects and procurements to design and provide those aircraft capabilities; and (4) conducting seminars, workshops, and other meetings to facilitate all of the above.

## Hydrologic Processes

**W93-70318****461-10-00**

Marshall Space Flight Center, Huntsville, AL.

**HYDROLOGIC PROCESSES, FIELD STUDY**

R. J. Koczor 205-544-3078

The objective of this RTOP is to contribute to the NASA Hydrologic Processes, Field Study Program by conducting applied research and development activities using space-related techniques and observations that will increase the basic understanding of the earth's hydrologic cycle. Utilizing the talents of university and private contractor groups, plus the MSFC in-house talents and laboratory capabilities, specific research activities as described in the tasks of this RTOP will be accomplished.

**W93-70319****461-13-00**

Goddard Space Flight Center, Greenbelt, MD.

**VALIDATIONS OF PASSIVE MICROWAVE SNOW WATER EQUIVALENT ALGORITHM**

A. T. C. Chang 301-286-8997

Algorithms have been developed to retrieve snow parameters from passive microwave data with some success over the Canadian prairies and the Russian steppes. However, the accuracy and error limits of these algorithms when applied to different geographic regions is not well known. The objectives of this effort are as follows: (1) to validate the snow retrieval algorithms for different

geographic and physiographic regions; and (2) to investigate the potential of active microwave signature (e.g.,) synthetic aperture radar (SAR) for snowpack property monitoring. Snow retrieval algorithms will be applied in selected regions, such as the Canadian boreal forest, the Alaskan tundra, and the Tibetan plateau to obtain snow water equivalent (SWE) estimates using Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I) data. These estimated SWE values will be compared to the ground observed SWE to assess the accuracy and problems associated with the existing retrieval algorithms. Refined algorithms will take into account the effects of vegetation cover, topography, grain size distribution, and mixed pixel problems. Improved snow retrieval algorithms for different physiographic regions will be applied to SSM/I data to produce weekly/monthly global snow storage maps. SAR data over snow fields will be collected to study its potential for snowpack property monitoring.

**W93-70320****461-13-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MEASURING SOIL MOISTURE WITH IMAGING RADAR**

J. J. vanZyl 818-354-1365

The purpose of this investigation is to study the feasibility of measuring soil moisture with imaging polarimetric synthetic aperture radars (SAR's). Polarimetric SAR data were acquired during two hydrology experiments during FY-91, one in Spain and one in Italy. We shall use models of radar scattering to invert the radar data to find the surface dielectric constant. The values inferred from the radar data will be compared with the in-situ measurements to assess the feasibility of measuring dielectric constants using polarimetric SAR data. Once the dielectric constants are known, we shall use existing soil models to invert the dielectric constant values to infer soil moisture. In addition, we shall participate in a hydrology experiment in Oklahoma in 1992. We shall deploy calibration equipment and make point measurements of soil moisture during the experiments. We shall calibrate the data and co-register images from different dates. All calibrated data will be distributed to interested investigators.

**W93-70321****461-13-01**

Goddard Space Flight Center, Greenbelt, MD.

**MODELING AND MULTISPECTRAL SATELLITE DATA ANALYSIS FOR LAND SURFACE STUDY WITH SPECIAL EMPHASIS ON HOT ARID AND SEMI-ARID REGIONS**

Bhaskar J. Choudhury 301-286-5155

(579-42-02)

The objectives of this RTOP are: (1) to quantify seasonal and inter-annual variations of surface wetness, temperature, microwave polarization difference and spectral vegetation indices over hot arid and semi-arid regions of northern Africa and southeastern Australia for the period 1979 to 1990 using Scanning Multichannel Microwave Radiometer (SMMR), Advanced Very High Resolution Radiometer (AVHRR), Thematic Mapper (TM), and Special Sensor Microwave/Imager (SSM/I) data; and (2) to perform radiative transfer and heat balance simulations to understand this data in terms of land surface prognostic and diagnostic variables. A predictive model for surface wetness will be developed based upon SMMR 6.6 and 37 GHz data and tested over an independent region within the U.S. Southern Great Plains. Then the SMMR data will be used to produce soil moisture maps for northern Africa and southeastern Australia for the period 1979 to 1990. Radiative transfer and heat balance models will be used with daily or monthly meteorologic data acquired from the National Climate Center to simulate reflectances, vegetation indices, and surface temperature. Methodology for correcting the satellite data for atmospheric effects will be developed. SMMR and SSM/I 37 GHz data will be compared. The simulated relations between the multispectral data will be compared with the observed relations to evaluate the relative sensitivity to varied surface and environmental characteristics.

**W93-70322****461-13-02**

Goddard Space Flight Center, Greenbelt, MD.

**DESERT MESOSCALE/PBL**

Edwin T. Engman 301-286-5480

In this study we will test and validate a series of routines that could eventually be used in a General Circulation Model (GCM) to address the surface-to-atmosphere linkages of arid regions. This is important because almost one-third of the Earth's land surface area is arid. We will focus on three strategies: (1) testing our ability to use remotely sensed data to derive the desert surface moisture and soil types - by using the proper techniques, one should be able to develop the large-area surface classifications needed to initialize mesoscale climate model runs; (2) measuring a regional-scale ground truth data base that can be used to test the classification development schemes and the mesoscale models of the surface heat transfer; and (3) performing detailed mesoscale modeling of the local area flux units to determine how they combine to provide regional level responses.

**W93-70323****461-31-09**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SCATTEROMETER RESEARCH**

F. K. Li 818-354-2849

The objective of this task is to improve our understanding of the quantitative relationship between radar backscatter from the ocean and geophysical parameters such as near surface winds through airborne scatterometry experiments. The primary FY-93 objectives are to continue the analysis of the results obtained by New Airborne Scatterometer (NUSCAT) during the Surface Wave Dynamics Experiment (SWADE) in order to evaluate the effects of long waves, the magnitude of depolarization, and the intercomparison of Ku- and C-band backscatter behavior across the Gulf Stream boundaries. A secondary objective is to continue interacting with NASA Headquarters on the future disposition of NUSCAT. In FY-92, we have completed the re-calibration of the major components of the NUSCAT system. The radar measurements were then converted to calibrated backscatter cross sections. We have also identified three specific data sets for detailed studies: (1) low wind data collected on 1 Mar. 1991; (2) comparison of low and high wave situations; and (3) a collection of Gulf Stream boundary crossings that had large changes of air-sea temperature difference. In FY-93, we will complete these studies and document the results in publications. We will also conduct a detailed study of intercomparison between the Ku- and C-band observations. In particular, we will examine the relative sensitivity to wind speed changes and the upwind/downwind/crosswind azimuth modulation depths. We will also perform an analysis of the cross polarization measurements and compare the level of depolarization observed to existing electromagnetic scattering theories. Finally, we will interact with NASA Headquarters on the disposition of NUSCAT.

**W93-70324****461-31-13**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SCATTEROMETER STUDIES**

P. M. Woiceshyn 818-354-5416

(578-42-10; 578-42-11)

The objectives of this RTOP are to: (1) assess the quality of the ERS-1 and Specialized Experimental Applications Satellite (SEASAT) scatterometer backscatter data and wind-vector retrieval procedures including the physical basis for these; (2) evaluate the accuracy of automated wind direction ambiguity removal procedures; and (3) evaluate the importance of physical processes such as sea surface temperature (SST) and wave age in the wind retrieval physics. This includes comparisons between measurements taken from the open sea and those from inland seas such as the Mediterranean. During part of the ERS-1 mission, (including the cal/val period), we will be on site at the European Center for Medium Weather Forecasts (ECMWF) connecting directly to European Space Agency's (ESA's) and ECMWF's databases with our own workstations. Basically, there will be four co-located types of data to be accessed: (1) ERS-1 scatterometer data; (2) buoy and ship reports; (3) windfield and other analyses

(e.g., SST); and (4) special cal/val data off the coast of Norway. The evaluation will include kinematic fields such as divergence and vorticity. We will convert the ECMWF analysis fields to backscatter to compare to scatterometer backscatter (NRCS) values. This procedure has proved fruitful with the ERS-1 and SEASAT scatterometer data in identifying speed and direction transfer (model) function anomalies not otherwise detected using traditional techniques. To assess the influences of physical parameters such as sea surface temperature and wave age, we will develop and test scatterometer functions utilizing non-dimensional analysis techniques that incorporate these parameters. Some progress has already been made in this area. With our co-investigator, Dr. Stefano Zechetto at CNR-Venice, (on an approved ERS-1 research task), we will analyze data records that will be taken from his tower-mounted C-Band scatterometer in the Adriatic Sea. Other sea and meteorological measurements will also be simultaneously recorded. We will then test various parameters that could prove to be important in the physics and consequently the retrievals of wind-vectors and wind stress from scatterometer in this environment. We will collaborate with co-investigators, Morton G. Wurtele (UCLA), Anthony Hollingsworth and Peter Janssen (ECMWF), Evert Attema (ESA-ESTEC), Pascal Lecomte (ESA-ESRIN) and Stefano Zechetto (CNR-Venice) in the scientific investigations and the establishment of the databases noted above.

**W93-70325****461-33-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ALTIMETER MEASUREMENTS OF WIND SPEED AND SEA LEVEL HEIGHT WITH APPLICATIONS TO AIR-SEA INTERACTION STUDIES: PHYSICAL PRINCIPLES AND ADVANCED TECHNIQUES**

R. E. Glazman 818-354-7151

Last year we completed the development of a new, physically-based, geophysical model function (GMF) for wind speed determination using altimeter radar cross section and significant wave height. The error trends associated with 'wave age' were reduced to a geophysically insignificant level in both the wind speed measurements and the sea state bias. Our work also resulted in some discoveries in the area of nonlinear wave dynamics. However, the research (including analysis of buoy data) indicated that the present understanding of energy and momentum exchange between the ocean and the atmosphere remains insufficient. A number of questions concerned with the energy and momentum transfer from wind to wave and current fields must be answered before correct input for ocean circulation models can be obtained from satellite measurements. Specifically, the roles of the direct and inverse energy cascades through the spectrum of surface waves must be better understood. Interactions between the inverse cascade and larger-scale motions have to be explored. The high-frequency range of the wave spectrum covering capillary-scale waves is also found to be important for the interpretation of microwave remote sensing signatures. Thus our current objective is to attain better understanding of air-sea interaction mechanisms in the areas mentioned above and, on that basis, improve the interpretation and expand the application of satellite measurements for ocean studies. Our approach is to carry-out an analysis of colocated buoy and satellite data (including ERS-1 altimeter and SAR wave-mode data) combined with theoretical studies on dynamics and statistics of sea surface roughness within a large range of scales: hundreds of kilometers to millimeters (capillary waves).

**W93-70326****461-34-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**RETRACKING OF TOPEX WAVEFORM DATA**

E. Rodriguez 818-354-5668

During the past years, we have developed advanced altimeter retracking algorithms and studied the correction of height errors induced by the nonlinear nature of the ocean surface. The objective of the continuing work is to apply these results in order to improve the Topographic Ocean Experiment (TOPEX)/Poseidon data set and make this data set available to the oceanographic community.

The improved data set will consist of high accuracy altimeter heights obtained by retracking the altimeter waveforms, an improved electromagnetic bias and altimeter mispointing corrections. The ultimate objective is to use the improved data set to investigate the characteristics of the global large-scale sea level variabilities. In order to perform the altimeter waveform retracking, we have adapted the sub-optimal maximum likelihood algorithm developed for the processing of Geosat data to handle the characteristics of the two-frequency, differently sampled TOPEX waveforms, and implemented the algorithm in an operational system able to handle TOPEX data in real time. Prior to launch, the algorithm has been tested for accuracy and speed performance using Monte Carlo experiments. After launch, we will use the verification period to assess the accuracy of the retracked data, and to provide independent confirmation of the TOPEX performance. During the TOPEX mission, we will then use the high accuracy TOPEX data set to validate and improve the TOPEX electromagnetic bias height correction algorithm by using repeat track data and over NDBC buoys. Finally, we will generate a smoothed, interpolated, data set sampled at 10 day intervals to extract and estimate the seasonal cycle, and study the dynamics governing the variabilities of the residual signal by regression analysis and Kalman filtering.

**W93-70327** **461-38-01**  
Goddard Space Flight Center, Greenbelt, MD.

#### **AIRBORNE ESTAR**

David M. LeVine 301-286-8059  
(462-26-01)

Salinity is a parameter of the oceans important for understanding ocean circulation and coupling to the global atmospheric and hydrologic cycles. Salinity can be measured with microwave radiometers using two channels (L- and S-band) to remove the effects of water temperature. However, measurements from space at these frequencies require large antennas to achieve adequate spatial resolution. The purpose of this research is to determine whether aperture synthesis can be used to achieve the required resolution with an antenna which it is feasible to deploy from space.

**W93-70328** **461-38-02**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**MONITORING GLOBAL SEA LEVEL WITH ALTIMETER TRANSPONDERS**  
E. J. Christensen 818-354-1992

Spaceborne altimeters measure sea level with a precision of a few centimeters and topographic features on land with a precision of only a few meters. Used in conjunction with altimeter transponders, the vertical height of fiducial sites on land can be measured with accuracies comparable to those obtained at sea. Therefore, altimeter transponders provide the unique opportunity to obtain internally consistent sets of high precision vertical height measurements taken on land and at sea. That is, selected fiducial sites on land can be tied to global sea level data sets produced by missions such as TOPEX/POSEIDON, ESA Remote Sensing Satellite-1 (ERS-1), and future altimeter missions. Altimeter measurements are generally gathered along a repeated groundtrack where the duration of the repeat cycle is typically 10, 17, or 35 days, depending on the mission and mission phase. Owing to the random nature of the measurements, long-term vertical motion of a specific site can be observed with a high degree of confidence. Therefore, altimeter transponders can be used to address questions pertaining to change in global sea level, motion of ice sheets, orogenic uplift, and isostatic adjustment. For these applications, it is proposed that the transponders be tied to the fundamental reference frame defined by the quasars using Very Long Baseline Interferometry (VLBI), and to the Earth's center using the Global Positioning System (GPS) and satellite laser ranging. It is proposed that dual frequency L1/L2 GPS receivers collocated with altimeter transponders be deployed along the TOPEX/POSEIDON groundtrack. Through differential GPS geodetic positioning, these sites will serve as control points for the network. The altimeter data, combined with the radial position of the orbit, will provide a spatially continuous record of sea level

relative to the land based fiducial sites at five- or ten-day intervals. The orbit will be determined using GPS, laser, and perhaps Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) tracking data. The tracking and transponder systems enable the tie of global sea level to the fundamental reference frame and to the Earth's center. Transponders can also be used to detect and measure episodic changes in the vertical due to earthquakes and volcanic eruption. Another important application is to deploy altimeter transponders on platforms at sea for calibrating the electromagnetic bias and, in the case of dual frequency altimetry, verify corrections for ionospheric delay. Transponders also lend themselves to removing once per orbit radial errors encountered in precision orbit determination.

**W93-70329** **461-38-05**  
Goddard Space Flight Center, Greenbelt, MD.  
**TRMM**

Otto W. Thiele 301-286-9006  
(461-57-01; 461-57-26)

The objective of this RTOP is to participate in the Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE) to make salinity measurements. The approach is to measure ocean salinity in the warm pool region of the western Pacific using a shipborne microwave radiometer.

**W93-70330** **461-50-00**  
Marshall Space Flight Center, Huntsville, AL.  
**HYDROLOGIC PROCESS STUDIES**  
R. J. Koczor 205-544-3078

The objectives are to perform a series of studies to assess current remote sensing capabilities to study earth processes and to study hydrologic processes using aircraft and ground-based instruments in various field programs. The talents of university and private contractor groups will be used to develop and measure hydrologic process through various field activities.

**W93-70331** **461-50-03**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**GEWEX PROGRAM SUPPORT**  
D. G. Vane 818-354-3708

The objective of this RTOP is to provide support to the NASA Global Change Program in: (1) developing the Global Energy and Water Cycle Experiment (GEWEX) for NASA; (2) planning for the GEWEX Continental-Scale International Project (GCIP); and (3) coordinating GCIP and GEWEX plans with the National Oceanic and Atmospheric Administration (NOAA) and other agencies.

**W93-70332** **461-51-16**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**AIRBORNE PRECIPITATION RADAR**  
F. K. Li 818-354-2849

The objective of this task is to develop an airborne rain mapping radar (ARMAR) to demonstrate accurate remote precipitation measurements. ARMAR will be used to verify the technique, technology and data processing algorithms for future satellite rain measurement missions, such as the planned Tropical Rainfall Measuring Mission (TRMM). It will also be used in the post-launch performance validation of such spaceborne rain radars. In FY-93, our primary objective is to conduct the first scientific rainfall measurement experiment with ARMAR during the Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE). ARMAR will be deployed on the NASA Ames DC-8 from January to March 1993 for about ten flights over rain events near the intensive observation area of TOGA/COARE in conjunction with other airborne and in situ measurements. We will complete an initial assessment of this data set by the end of FY-93. This initial assessment will include an evaluation of the system calibration accuracy throughout the experiment, the quantity of useful data over significant rain events and any initial comparison with in situ measurements. The other objectives in FY-93 are to procure the antenna and RF components of the 24 GHz channel and to initiate the incorporation of this second channel into ARMAR after the TOGA/COARE deployment.

In FY-92, the 14 GHz channel of ARMAR was fully fabricated and was tested on the ground in two rain storms around Los Angeles in late 1991 and early 1992. There are now two sets of engineering test flights on the DC-8 planned in May and July of 1992. The system will return to the Jet Propulsion Lab (JPL) after these tests and any system refinement required based on these test results will be conducted in the remainder of 1992. We will also perform a complete, detailed system calibration based on laboratory as well as airborne measurements. The ground processing system will be fully checked out using these engineering test results. Modifications of the on-board processor to enhance the near real-time visibility into the data collection procedure will also be performed. The actual TOGA/COARE deployment will be in the first two months of 1993. ARMAR will be installed on the DC-8 in December 1992 and about ten data flights over the TOGA/COARE experiment area will be conducted. The radar data will be processed into backscatter and Doppler measurements based on initial system parameters in the remainder of FY-93. The long lead items of the RF and antenna components of the 24 GHz channel will be procured and installed after the TOGA/COARE deployment. The fabrication of this second channel will be completed in FY-94.

**W93-70333** **461-62-10**  
 Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**MICROWAVE PROCESS STUDIES OF SEA ICE PROPERTIES**  
 M. R. Drinkwater 818-354-8189  
 (665-35-10)

Using existing and forthcoming data, the goal is to establish a methodology for combining microwave images recorded at various frequencies and polarizations, in order to provide a dataset from which the geophysical properties of sea ice can be inferred. Aircraft, satellite, and in-situ microwave data will be combined, and used in conjunction with empirical and theoretical models to characterize and quantify scattering and emission responses to variations in ice properties. The ongoing study focuses on Arctic and Antarctic ice types controlling surface fluxes of heat and salt, for instance, thin or young ice forms. The objectives are: (1) to participate in the Polarstern Winter Weddell Sea Experiment from May to July 1992 to make shipborne C-band multichannel microwave scatterometer and surface property measurements; (2) to obtain simultaneous Earth Resources Satellite (ERS-1) and Japanese-ERS-1 satellite Synthetic Aperture Radar (SAR) images during the Antarctic experiment; (3) to evaluate optimal frequency and polarimetric discriminators for ice properties in combined multichannel active and passive microwave data; and (4) to continue model simulation comparisons with SAR and scatterometer data to derive signatures characteristic of new and young snow-covered first-year ice of varying properties in calibrated radar data. The approach is to continue: (1) analysis of polarimetric covariance matrix data to determine unique sources of independent snow and ice properties information; (2) refinement of segmentations of distributed target scattering scene into recognizable scattering tendencies of key ice types, by combinations of polarimetric classification and target decomposition; (3) to extend the active-passive analysis of collocated March '88 Arctic microwave data by addition of the Chukchi Sea transect and then multivariate analysis of this Arctic-wide multiple channel SAR, Airborne Multichannel Microwave Radiometer (AMMR), K-band Radiometer Mapping System (KRMS) dataset; and (4) to develop techniques for extraction of geophysical information by model inversion.

**W93-70334** **461-64-11**  
 Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**POLARIMETRIC DATA ANALYSIS**  
 R. Kwok 818-354-5614

During March 1988, multi-frequency polarimetric radar data were collected in the Beaufort, Chukchi and Bering Seas with the Jet Propulsion Lab (JPL) airborne Synthetic Aperture Radar (SAR). These datasets can be used to obtain a better understanding of the scattering mechanisms of sea ice returns and extraction of features for discrimination of sea ice in polarimetric data as well as guide the design of classification algorithms for data from single

frequency, single polarization radars. Preliminary investigations utilizing C-, L- and P-band polarimetric data have concentrated on ice type discrimination and characterization in the digital images. Results suggest that polarimetric data can significantly enhance our ability to distinguish between open water, new ice and thicker smooth ice. The long term goal is to identify the ice types that can be unambiguously labeled in the multi-frequency, polarimetric SAR data utilizing available datasets and ground truths. The approach of the proposed work is to characterize the multi-frequency polarimetric signatures of sea ice in the aircraft data acquired during the 1988 campaign. The focus is on investigating the improvement of the discrimination capability of sea ice in the polarimetric data, the compilation of signatures of thin ice types in polarimetric SAR data, and characterization of the limitations of polarimetry using spaceborne sensors.

**W93-70335** **461-66-16**  
 Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**OCEANIC REMOTE SENSING LIBRARY**  
 D. Halpern 818-354-5327

The Oceanic Remote Sensing Library (ORSL) serves the research needs of JPL earth scientists involved in studies of ocean circulation, ocean-atmosphere interactions, biogeochemical cycles, atmospheric sciences, remote sensing technology, and climate and global change. With the high cost of periodical literature and with the large numbers of periodicals and technical reports, no individual investigator at JPL has adequate budget resources nor sufficient office space to acquire the necessary literature to conduct state-of-the-art research. ORSL maintains a collection of technical periodicals, reports, and books related to biological, chemical, and physical oceanography, atmospheric sciences, and relevant satellite missions. ORSL provides an efficient and effective circulation procedure. ORSL supports research activities of the oceanographers, including retrieval of scientific literature. ORSL provides an intellectually inspiring area with appropriate audio-visual equipment for meetings and conferences for small groups. ORSL maintains special collections of internal documents, which are available free-of-charge from universities, NASA Centers, ESA, WCRP, NOAA, and many other organizations. ORSL provides all library services to JPL researchers, including document retrieval.

**W93-70336** **461-66-18**  
 Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**ICE SHEET GEOPHYSICAL INVESTIGATIONS USING IMAGING RADAR**  
 F. D. Carsey 818-354-8163

The goal of this work is to investigate ice sheet geophysics using microwave synthetic aperture images in conjunction with surface observations. There is the very significant prospect that Synthetic Aperture Radar (SAR) observations can supply critical information on ice accumulation and ablation, ice motion and snow and firn properties. Seasat first collected SAR images, and they have raised a number of scientific questions relating to the opportunities of SAR with respect to the monitoring of glacial hydrology and ice sheet geophysics. High resolution Jet Propulsion Lab (JPL) multiple-channel airborne SAR datasets collected in 1989 and 1991 over Greenland form the basis for interpretation of future Earth Resources Satellite (ERS-1) and Japan's ERS-1 satellite imagery and for the development of future observation systems. The objectives of this RTOP are: (1) Extract key surface features such as distinct snow regimes and drainage patterns from the imagery; (2) Assess present utility and optimize SAR data products and develop techniques to investigate the penetration of the SAR wavelengths into the ice sheet surface and to determine the consequences to SAR processing from the penetration along with SAR data analysis tools; and (3) Develop methods to extract local topographic effects from radar imagery by data fusion with altimetry data, digital terrain models and other satellite data. The approach is to: (1) Process and analyze multi-channel airborne synthetic aperture radar (AIRSAR) data acquired in August 1989 and June 1991, during transit flights over the southern Greenland ice cap; (2) Optimize SAR data products and generate and distribute to the glaciological community a calibrated Greenland high resolution



ice sheet image dataset for polarimetric analysis along with SAR data analysis tools; (3) Conduct a polarimetric analysis of the backscatter signatures observed from different snow and ice facies; (4) Plan and conduct an Antarctic flight campaign to image critical ice sheet areas with significant surface measurement programs, as part of planned deployment of AIRSAR to Australia in 1993; and (5) Support ERS-1 and Japan's ERS-1 data acquisition over Greenland and Antarctica.

## Ecosystem Processes

### W93-70337

462-21-00

Ames Research Center, Moffett Field, CA.

#### FOREST/CLIMATE INTERACTIONS

D. L. Peterson 415-604-5899

The goal of this research is to test the extent of which stand-level models of forest evapotranspiration and net primary production can be extrapolated to regional scales. Under development is a computer simulation system to conduct these tests. The input fields to the model consist of important environmental variables such as surface temperature, precipitation, soil type, and leaf area index. The process model is based on FOREST-BGC, developed by Dr. S. Running and J. Coughlan (University of Montana) and MTN-CLIM, a meteorological model developed for mountainous terrain, also developed at Montana. The output fields generated by the model include photosynthesis and evapotranspiration. The simulation system, formerly called the Regional Ecosystem Simulation System (RESSYS), was recently renamed to the Regional Hydroecological Simulation System (RHESSYS) to reflect the fact that a hydrological routing model was added to the system. The hydrological module, a version of TOPMODEL by Beven and Kirby (1979) modified by L. Band and his collaborators at the University of Toronto, moves water from one spatial unit to its neighbors depending on its slope and soil parameters. Current work is focussed on the improved parameterization of input fields using geostatistical methods, and on the development of a modelling assistant to provide an environment for building and modifying a scientific model. The latter will be used for modifying or redesigning the process model for RHESSYS.

### W93-70338

462-26-01

Goddard Space Flight Center, Greenbelt, MD.

#### SYNTHETIC APERTURE MICROWAVE RADIOMETER

David M. LeVine 301-286-8059

(461-38-01)

Soil moisture is a highly variable element of the hydrologic cycle which is important in understanding the global hydrologic cycle and its coupling to the atmosphere and effect on climate as well as being important in agricultural management. Surface moisture can be monitored from space using radiometers operating at the low end of the microwave spectrum (e.g., L-band) because of the strong dependence of the dielectric constant of soil on its moisture content and the ability of radiation at these wavelengths to penetrate vegetation. However, the long wavelengths mean that large antennas are needed in orbit to obtain global maps of soil moisture. This research is to develop a technique to create the required large antenna apertures, synthetically, using pairs of small antennas and signal processing. The technique is called aperture synthesis and involves making measurements with pairs of antennas at many different antenna spacings. The technique has been successfully demonstrated using an aircraft prototype instrument developed in previous research in this program. (The prototype is a hybrid instrument which obtains resolution along-track using real antennas and resolution cross-track using aperture synthesis.) The objective of the present research is to calibrate

the instrument and validate its performance through participation in hydrologic field experiments.

### W93-70339

462-31-63

Goddard Space Flight Center, Greenbelt, MD.

#### LASER INDUCED FLUORESCENCE: A TECHNIQUE FOR REMOTE ASSESSMENT OF PHOTOSYNTHETIC EFFICIENCY AND DETECTION OF ENVIRONMENTAL STRESS

Emmett W. Chappelle 301-286-6638

The objectives of our investigations are: (1) the development of the Laser Induced Fluorescence (LIF) technique as a means of assessing photosynthetic efficiency at leaf and canopy levels; (2) detection of environmental damage to vegetation as evidenced by changes in fluorescence spectra; and (3) development of algorithms using reflectance spectra for the remote estimation of the plant constituents involved in photosynthesis. LIF and reflectance measurements will be made on greenhouse plants which will be grown under different levels of nutrient stress in order to obtain a range of physiological states which will insure different rates of photosynthesis and different pigment concentrations. Field measurements comparable to those made on the greenhouse plants will be conducted on plant canopies.

### W93-70340

462-32-00

Ames Research Center, Moffett Field, CA.

#### LAND SURFACE CLIMATOLOGY: HAPEX

M. A. Spanner 415-604-3620

(462-31-62)

The objective of this work is to participate in the Hydrologic Atmospheric Pilot Experiment (HAPEX) in Niger in 1992. Ames Research Center participation will involve the measurement of aerosol optical properties from ground and aircraft Sunphotometers, examination of the variability and characteristics of the aerosols, and correction of remotely sensed data acquired during the experiment for atmospheric effects.

### W93-70341

462-32-03

Goddard Space Flight Center, Greenbelt, MD.

#### VARIATIONS OF SOIL MOISTURE AND OTHER SURFACE PARAMETERS DURING HAPEX-SAHEL EXPERIMENT

Bhaskar J. Choudhury 301-286-5155

The objectives are to evaluate spatial and temporal variations of soil moisture during the HAPEX-Sahel experiment, and the synergism between multispectral observations (visible, near-infrared, infrared and microwave emission at 37 GHz) for estimating vegetation characteristics. The approach employs aircraft observations along transects over the HAPEX-Sahel test area following rain storms using the Push Broom Microwave Radiometer (PBRM) at 1.4 GHz frequency to estimate spatial and temporal variations in soil moisture. Concurrent aircraft observations by the Thematic Mapper simulator (NS001), Thermal Infrared Multichannel Scanner (TIMS), and dual polarized 37 GHz radiometer will be analyzed through radiative transfer models to estimate vegetation characteristics, which will be compared against ground measurements.

### W93-70342

462-32-61

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### ECHIVAL FIELD EXPERIMENT IN DESERTIFICATION-THREATENED AREA (EFEDA)

D. L. Evans 818-354-2418

The objectives are (1) to develop the area-averaged parameterization of the water and energy transfer between soils, vegetation and atmosphere within the ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)-Spain study site; (2) to estimate surface soil and vegetation parameters from Synthetic Aperture Radar (SAR) and other remote sensing data; and (3) to estimate the evapotranspiration over the entire EFEDA basin using parameters estimated from remote sensing data. The main focus is on the estimation of the evapotranspiration of the EFEDA site by using parameters derived from SAR and other remote sensing data. Our approach can be summarized as follows. (1) We propose to use the unsupervised classification algorithm developed by van



Zyl (1989) to distinguish between bare and vegetated areas in the EFEDA basin and to generate classified images based on the level of volume, surface, and double-bounce scattering mechanisms. (2) The inversion algorithms developed at the Jet Propulsion Laboratory (JPL) for inferring soil moisture and vegetation water content will be improved to include various agricultural crops. The algorithm will be applied to SAR data and images of estimated parameters will be generated. (3) We will use the estimated parameters from SAR data and other remote sensing information to calculate the evapotranspiration from the surface. We will adjust the scale of the parameters and will generate maps of evapotranspiration over the entire basin.

**W93-70343** **462-41-61**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**SATELLITE RADAR FOR FOREST STRUCTURE**  
J. B. Way 818-354-8225  
(579-41-08)

Multi-temporal measurements of forest ecosystems may be critical in resolving ambiguous interpretations of microwave backscattering from architecturally complicated forest canopies in the presence of spatial and temporal variability in scene characteristics. It is postulated that multitemporal microwave observations can be utilized to separate weather related scene variance from phenologic development. In addition, changing seasonal environmental conditions enhance or subdue certain components of the radar backscatter. The key questions being addressed in this study are: (1) what are the magnitudes of seasonal variation in the microwave backscattering coefficient as a function of wavelength and polarization vectors in response to naturally occurring temporal variability in monospecific forest stands which are characteristic of the temperate deciduous and coniferous forests and boreal forests; (2) how are these variations in the backscatter coefficient quantitatively related to specific forest stand and environmental properties via the relevant scattering mechanisms; (3) can SAR data be adequately calibrated (in both a relative and an absolute sense) to permit use of the data in conjunction with microwave scattering models, to permit its use in multitemporal comparisons and to permit site to site comparisons of globally distributed forests; and (4) given the observed temporal variations in backscatter, what ecologically useful information can be inferred from multitemporal SAR observations. To address the above questions, we are using multi-season ERS-1, JERS-1, and AIRSAR data sets of sites in the U.S. including the Bonanza Creek Experimental Forest in Alaska, the Duke University Research Forest in North Carolina and the Michigan Biological Station in Michigan. Ground truth measurements collected simultaneously with the aircraft and satellite data are being used in conjunction with existing radar models to determine which of the canopy properties are contributing to the backscatter at all wavelengths and polarizations. To date, freeze-thaw, stress from frost, drought, and flooded conditions have been obtained in Alaska, summer drought stress and flooded conditions have been obtained over Duke, and winter snow and summer rain/no-rain data sets have been acquired over Michigan with AIRSAR. Approximately 50 ERS-1 scenes have been obtained over both Michigan and Alaska between summer and winter of 1991. Additional data sets will be acquired through 1994.

**W93-70344** **462-43-00**  
Ames Research Center, Moffett Field, CA.  
**BIOGEOCHEMICAL CYCLING RESEARCH ON THE OREGON TRANSECT**  
D. L. Peterson 415-604-5899  
(199-30-72)

The objectives of this project are to measure the processes of carbon, nitrogen and water cycling through terrestrial ecosystems and to develop the principles of how nitrogen and water interact to control carbon assimilation and allocation in intact ecosystems. The approach is to test an existing ecosystem model of carbon, nitrogen and water fluxes and interactions through a combination of field and remote sensing studies during an intensive multisensor aircraft campaign. This test of principles, involving surface climate,

nutrient cycling and remote sensing, will be used to specify minimum general measurements. These techniques will then be expanded to companion sites the following year, and to support a workshop in the third year. Sensor data from a Canadian instrument, the Fluorescence Line Imager, will be added to the data set.

**W93-70345** **462-43-00**  
Ames Research Center, Moffett Field, CA.  
**BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS**  
D. L. Peterson 415-604-5899  
(462-43-00)

The objectives of these projects are to model the processes of carbon, nitrogen, and water cycling through temperate coniferous forests and to develop the principles of how nitrogen and water interact to control carbon assimilation and allocation, and to examine the effects of disturbances on these processes. The approach is to test an existing ecosystem model of carbon, nitrogen, and water fluxes and interactions through a combination of field and remote sensing studies during an intensive multisensor aircraft campaign. This test of principles, involving surface climate, nutrient cycling, and remote sensing, will be used to specify minimum general measurements. These techniques will then be expanded to companion sites the following year. To examine the effects of disturbance on nitrogen and water interaction, studies of how biomass combustion alters element pathways and losses will be made in collaborative experiments, emphasizing the use of remote sensing methods. In the third year, a workshop will be held to evaluate the field results.

**W93-70346** **462-61-00**  
Ames Research Center, Moffett Field, CA.  
**OPTICAL SCATTERING OF PLANT CANOPIES**  
V. C. Vanderbilt 415-604-4254

The objective of this project is to determine the relationships between the polarized light scattering characteristics of leaves and plant canopies and the biological properties of the leaf/plant such as plant development stage and leaf relative water content. The effect of the atmosphere on polarized light from plant canopies will be investigated. The approach involves studies conducted at three levels - laboratory, field, and aerospace. In the laboratory and field phases of the research, both single leaves and plant canopies will be measured allowing comparison of their spectral polarized light scattering properties and their physiological and morphological characteristics. The aerospace portion of the research will be conducted with the aid of a specially modified polarization scanner which will be flown on the ER-2. Targets of known light scattering characteristics will be measured on the ground and from the ER-2, thereby allowing the effect of the disturbing atmosphere to be better understood and modelled.

**W93-70347** **462-61-03**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**HETEROGENEOUS SCENE MODELS**  
D. J. Diner 818-354-6319

Quantitative studies of the surface from space require the ability to infer accurate spectral reflectances, bidirectional reflectance distributions, and hemispherical albedos from top-of-atmosphere (TOA) radiances. The purpose of this RTOP is to develop and test practical methods for retrieving these land surface (and required atmospheric) properties which meet the accuracy requirements of the scientific community and apply these methods to multi-angle image data sets currently available. We have the following objectives: (1) development of surface reflectance retrieval algorithms; (2) development of atmospheric optical property retrieval algorithms; (3) validation of these algorithms through retrieval of atmospheric optical properties and surface reflectance properties using Advanced Solid State Array Spectroradiometer (ASAS) multi-angle, multi-spectral image data; and (4) assessment of polarization and topographic effects. Determination of the radiance arising from photons diffusely transmitted from the surface to space must be computed using radiative transfer algorithms and our surface and atmosphere

retrievals are based on this formalism. Our radiative transfer-based retrieval code currently includes surface reflectance heterogeneity and directional properties. Our approach to retrieval of atmospheric aerosol optical properties (opacity, single-scattering albedo, and size distribution parameter) is dependent on the information content of off-nadir imagery. Our radiative transfer codes are able to compute the necessary nadir and off-nadir angle radiation fields associated with the retrieval algorithms and therefore we are able to model realistically the ASAS image data. A long term objective is to apply our techniques to EOS instruments, particularly the Multi-angle Imaging SpectroRadiometer (MISR).

**W93-70348****462-62-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**RADAR SCATTERING INVERSION: FORESTED AREAS**

H. A. Zebker 818-354-8780

The specific objective of this study is to improve our understanding of the interaction of radar signals with forested terrain, with the goal of developing algorithms permitting the inversion of remotely-sensed radar measurements to solve for geophysical factors describing the various forest canopies around the world. Specifically, we will first address the issue of biomass estimation, important for carbon cycle modeling. Previous theoretical modeling has indicated that the measured radar cross section is dominated by various scattering mechanisms depending on forest parameters such as branch, leaf, and trunk density, dielectric constant and height of trees, and roughness and permittivity of the forest floor. Therefore, it should be possible through radar measurements to recover the quantities that enable us to define the physiological state of the forest in terms of the canopy structure and vegetation composition, and also to investigate its dynamical behavior as a function of varying temperature, precipitation, and other atmospheric effects. Our modeling approach is to use a layered discrete scatterer model, in which each scatterer such as a twig or leaf is individually modeled, then combined statistically with other scatterers to form the aggregate radar interaction model corresponding to a layer of scatterers. These layers are then combined as required to completely describe the backscatter process from that modeled forest. The advantages of this approach are that the number of layers may be varied to account for different forest structures, and that the predicted scattering is quite well related to individual densities of the scattering elements (branches, leaves, trunks, and the like). A sensitivity study carried out using our forward scattering model has shown that radar backscatter cannot directly be used to determine biomass uniquely, since (1) as the biomass increases, the radar measurements saturate at all frequencies, and (2) before saturation, the increase in measured cross section is not uniform, i.e., a change in biomass does not guarantee a change in cross section. The latter is due to nonuniqueness in the set of forest parameters producing the same radar measurement. The same study, however, has shown that the radar measurements at all frequencies are sensitive and related to dielectric constant, density, and size of trees over reasonable ranges. It is the goal of this study to determine these ranges and produce workable inversion algorithms.

**W93-70349****462-62-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SOIL MOISTURE FROM SAR**

S. S. Saatchi 818-354-1051

The purpose of this investigation is to optimize the use of active and passive microwave remote sensing measurements for inferring soil moisture information. This study concentrates on the estimation of soil moisture in agricultural crops and grass fields. We propose to develop and calibrate backscatter and emission models for vegetated canopies and combine these models in order to make use of both active and passive data sets. The final combined model will be used to develop an inversion algorithm in order to use the Jet Propulsion Laboratory (JPL) Airborne Synthetic Aperture Radar (AIRSAR) and NASA Push Broom Microwave Radiometer (PBMR) images and retrieve soil moisture. We propose to participate in field campaigns such as MACHYDRO-90, ECHIVAL

(European International Project on Climate and Hydrological Interactions between Vegetation Atmosphere and Land Surfaces) Field Experiment in Desertification Threatened Areas (EFEDA) in Spain, and MACHYDRO-92 in Oklahoma. The data collected in these experiments will be used to test our algorithm.

**W93-70350****462-74-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AIRBORNE INTERFEROMETRIC TOPOGRAPHY**

H. A. Zebker 818-354-8780

(465-67-04)

The objective of this study is to develop an instrument capable of mapping the topography of the Earth's surface at high spatial and vertical resolution, using the technique of radar interferometry to produce a data set which is useful in a variety of Earth science investigations. Our specific objectives here are to implement such an instrument on an aircraft system in order to prove the technology in an operational environment, begin to acquire and distribute a data set over a variety of terrain types which will be available to the science community, and develop algorithms and procedures applicable to future spaceborne missions such as TOPSAT. Our approach, consisting of an instrument we call TOPSAR, is to implement a cross track interferometer mode on the existing NASA DC-8 radar for precision topographic mapping. This approach is of minimum cost as it utilizes the existing C-band multichannel radar hardware as much as possible. The major changes required to the existing system are procurement of two new radar antennas, fairings for mounting them on the DC-8, and changes to the radar RF switching network. Eventually, a new radar processor which produces low phase noise images will be needed. Our goal is to produce better than 2 m height accuracy DEM's with precisely co-registered L and P band polarimeter radar images. This capability follows from operating the L and P band systems simultaneously with the interferometer, and processing the raw data in an integrated manner. This will result in geometrically rectified and cartographically accurate polarimeter data. The three year approach is to (1) develop a new set of interferometric radar antennas, integrate them with the DC-8, and verify the installation with test flights in the U.S. and Italy; (2) develop a phase-accurate processor with aircraft motion compensation algorithms, and produce a sample 2 m map; and (3) integrate the system with the DC-8 P and L band radars in a manner that will allow it to be operated in a routine manner, should NASA wish to fund it as part of the AIRSAR system. In addition, we will, during the course of this study, acquire data over a variety of sites of differing Earth science applications to support the science community at large and familiarize them with the generation and use of digital topographic data.

**W93-70351****462-75-62**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATIONS**

J. J. vanZyl 818-354-1365

(465-68-01; 665-81-08)

The purpose of this plan is to provide the NASA remote sensing program with an Airborne Synthetic Aperture Radar (AIRSAR) system for purposes of testing and evaluating radar techniques in parameterizing surface physical characteristics. In addition, this work serves to develop engineering methods that can be and are used to fabricate spacecraft Synthetic Aperture Radar (SAR) systems. AIRSAR is a three-frequency (P-, L- and C-band), fully polarimetric SAR that acquires all twelve data channels simultaneously, resulting in co-registered images at all frequencies. In FY-93, the AIRSAR will be maintained and operated during flight missions as prescribed by NASA. The data will be converted to imagery and disseminated to the users in accordance with procedures established by NASA and the Jet Propulsion Laboratory (JPL). Flight hours for engineering testing will be used to assure the proper performance of the SAR and to test new concepts planned for future spacecraft SAR's. The plan is to reduce the data from up to 600 scenes to three-frequency imagery, each with four polarizations (12 images). System evaluation will be carried

out to assess the validity of the data. We shall calibrate the AIRSAR data using the results from calibration flights over Rosamond Dry Lake in California. An upgraded ground data processing facility will be completed in FY-92 under separate funding; the new system will allow improvements to be made in data quality and increase the processing throughput.

**W93-70352** **462-75-74**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**THERMAL INFRARED SCIENCE SUPPORT**  
V. J. Realmuto 818-354-1824

The overall objective of this RTOP is to advance the science of thermal infrared remote sensing. This objective will primarily be achieved through the use of image data acquired with the Thermal Infrared Multispectral Scanner (TIMS). The science support task described in this RTOP is divided into two elements: (1) operations and user support; and (2) instrument support. The Jet Propulsion Laboratory (JPL) will serve as the point of contact for active and future TIMS investigators, assist in the planning of TIMS missions, maintain a library of operation logs and flight reports, and maintain a library of color-composite TIMS images to serve as browse products. In addition, JPL will continue to host the annual TIMS Airborne Geoscience Workshop, maintain a laboratory spectrometer facility for the use of TIMS investigators, and distribute historic TIMS data held in the JPL tape archives. This last duty will be phased out during FY-93 as the United States Geological Survey (USGS) Earth Resources Observation Systems (EROS) Data Center (EDC) assumes the responsibility for distributing historic TIMS data under Version 0 of Earth Observation System Data and Information Systems (EOSDIS). JPL will continue to monitor the performance of the TIMS instrument, conduct field calibration exercises, and design algorithms for the reduction and analysis of TIMS data. Beginning with the FY-92 flight season, JPL will receive copies of the data from all TIMS missions flown out of the NASA/Ames Research Center (NASA investigators will continue to receive their data directly from AMES). These data will be used to evaluate the performance of TIMS: (1) the housekeeping data recorded on the TIMS data tapes will be examined; (2) the digital numbers (DN's) recorded by TIMS will be reduced to radiance values and these values will be examined; and (3) decorrelation stretches (a contrast enhancement algorithm) of the TIMS data will be examined to evaluate instrument noise. Following the performance evaluation, the decorrelation-stretch images and radiance data products will be sent to the appropriate principal investigators. The new JPL thermal infrared calibration (TIRCAL) facility will be used to evaluate the spectral and radiometric response of TIMS. Field calibration exercises will be conducted near Castaic Lake and the Salton Sea, which are both easily accessible from JPL.

**W93-70353** **462-76-49**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**VISITING SCIENTISTS**  
D. J. McCleese 818-354-2317

The objective of this task is to provide support to Drs. Ram Oren and Reiner Zimmerman in their efforts to measure directly and continuously, for the first time in boreal plant communities, the annual and diurnal changes of transpiration and canopy conductance. They will also measure several micro-climatic variables, stem water content, and plant water potential. These variables will provide: (1) a direct estimate of canopy conductance for models ranging in scale from the stand to the region; and (2) an understanding of ecophysiological differences among major community types which will aid in predicting their responses to changes in climatic conditions as predicted by the models. These variables and the information which will result from their study are the key to many proposed activities in the context of BOREAS, and can be used to test and expand the use of remotely sensed data to evaluate changes in the structure and function of plant communities.

**W93-70354** **462-79-00**  
Ames Research Center, Moffett Field, CA.  
**AIRBORNE SCIENCE MANAGEMENT OPERATING WORKING GROUP SUPPORT**  
J. G. Lawless 415-604-5900  
(465-69-00; 460-99-00)

The objective of this work is to provide general support to NASA's Airborne Science Management Operation Working Group. Support will be provided for planning activities related to Earth Surface Remote Sensing Program usage of NASA's science applications aircraft. Staff support is also necessary for regular meetings of the Aircraft Science Management Operations Working Group.

## Biogeochemical Processes

**W93-70355** **463-11-01**  
Goddard Space Flight Center, Greenbelt, MD.  
**SEAWIFS CALIBRATION/VALIDATION**  
Robert G. Kirk 301-286-7895

This RTOP covers part of the NASA in-house associated with the POP for the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) Spaceflight System. It supports the algorithm development and data calibration and validation programs.

**W93-70356** **463-11-09**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**PHYTOPLANKTON DYNAMICS OF NORTH PACIFIC OCEAN**  
C. O. Davis 818-354-5395

This research focuses on the use of AVHRR sea surface temperature (SST) and ocean color data from the CZCS and future instruments for the study of primary productivity and phytoplankton dynamics in highly productive ocean systems. Initially, the focus is on using extensive in situ data for optical characterization of major oceanographic regions and for verification and interpretation of the satellite data. Subsequently, the goal is to use the satellite data validated with mooring data coupled with models based on the cruise data to extrapolate those results in time and space to produce regional estimates of phytoplankton biomass and production. Study areas to date include: the coastal upwelling systems along the California coast, the North Atlantic Spring Bloom, and the equatorial Pacific. Extensive in situ optical data were collected in each of these study areas in collaboration with large field experiments. Those data have been processed and algorithms for using optical data to estimate phytoplankton biomass and productivity are being developed. In the past year we developed a data base system for this data and all future in situ optical data which includes the calibrated data and a library of readily applied algorithms for ship shadow correction, quality control checks,  $K(\lambda)$ ,  $L(\text{sub } W)(\lambda)$ , etc. Beyond this we are using satellite ocean color and SST data in total and new production models and eventually in coupled physical-biological models to obtain regional and basin scale estimates of phytoplankton productivity. This project is considered a component of the Joint Global Ocean Flux Study (JGOFS), an international study of the flux of carbon through the ocean. We have collected in situ optical data as part of the JGOFS 1989 North Atlantic Bloom Experiment and this year as part of the Spring Equatorial Pacific Experiment. We will also participate in the Fall Equatorial Pacific Experiment in September-October 1992.

**W93-70357** **463-11-62**  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**BIO-OPTICAL INTERPRETATION OF OCEAN COLOR IMAGERY**  
D. J. Collins 818-354-3473

The objectives of this research are the description of the

spatial and temporal distributions and variability of the planktonic community in the sea and of the primary productivity of that community on seasonal to interannual time scales and regional to global spatial scales, and the description of the coupling between the phytoplankton populations of the surface mixed layer and the physical environment of the near-surface waters. The objectives will be achieved through the use of remote sensing for a description of the near-surface radiance and irradiance fields, pigment concentration, the sea-surface temperature, and the incident solar irradiance. We will extend our present research in the modeling of marine primary productivity through a description of the carbon flux in the near-surface waters. We will continue the verification of the model through the comparison of the model results with existing data bases in selected regions representing differing oceanographic environments. Presently we are using remotely sensed data for the description of the seasonal variability of the water column primary productivity of the global ocean and exploring the spatial and temporal distributions of phytoplankton biomass, primary productivity, and carbon flux in the equatorial Pacific Ocean upwelling area and in the oligotrophic central Pacific gyre in conjunction with the U.S. Joint Global Ocean Flux Study (JGOFS) activities in these regions. These studies include an analysis of the Multichannel Sea Surface Temperature (MCSST) and Coastal Zone Color Scanner (CZCS) pigment imagery to describe a time series of pigment and temperature in the global ocean. This research utilizes the techniques of neural nets for the spatial and temporal interpolation of the satellite derived data fields.

**W93-70358****463-11-79**

Wallops Flight Facility, Wallops Island, VA.  
**AIRBORNE OCEANOGRAPHIC LIDAR (AOL)**  
 F. E. Hoge 804-824-1567

The primary objectives of this RTOP are to continue the scientific and instrument research development, and applications of the NASA/GSFC Airborne Oceanographic Lidar (AOL) leading to improved understanding of global biogeochemical cycling using both active and passive measurements of phytoplankton chlorophyll, phycoerythrin, and phycocyanin pigment and dissolved organic matter. Our approach is to focus efforts upon: (1) continued cooperative field investigations with widely-recognized oceanographic institutions, government laboratories, and field centers; (2) continued improvement of the airborne pulsed laser measurement of subsurface scattering layers using the AOL; and (3) direct application of active-passive correlation spectroscopy (APCS) to AOL data for advanced ocean color satellite sensor band selection and algorithm development. Specifically, continue/initiate interagency cooperative oceanographic field investigations such as: (1) the Joint Global Ocean Flux Study (JGOFS), NOAA/NSF Climate and Global Change Program, and DOE's new Ocean Margins Program and Global CO<sub>2</sub> Survey in the Ocean Program; (2) improving the temporal/depth-resolved electro-optical components of the AOL to allow the detection and quantitative measurement of particulate volumetric backscatter over a wide range of signal levels; (3) participating in the JGOFS Central Equatorial Pacific Experiment and data analyses; and (4) conducting ocean color experiments using the dual active/passive modes of the AOL such as active (lidar) validation of passive ocean color in-water algorithms especially as they may relate to planned Earth Observing System/Moderate Resolution Imaging Spectrometer EOS/MODIS satellite sensor and the satellite Sea-Viewing Wide Field-of-View Sensor (SeaWiFS).

**W93-70359****463-43-00**

Ames Research Center, Moffett Field, CA.  
**REGIONAL CARBON FLUX IN HIGH LATITUDE ECOSYSTEMS**  
 G. P. Livingston 415-604-3232  
 (148-90-00)

This research addresses the regional-seasonal estimation of carbon flux and the regulatory exchange processes for select northern high-latitude ecosystems. The approach is through integration of in-situ flux observations, simulation modeling, and land surface stratifications based upon satellite and aircraft remote sensing. Initial surface observations will determine the magnitude

and variability of methane and carbon dioxide emissions along select environmental gradients to characterize the regulatory biogeochemical processes. Net emissions will be estimated within ecological spatial strata derived from SPOT, TM, AVHRR, SAR and CIR photography. Various estimation approaches of regional flux will be assessed based upon chamber, eddy correlation, and isotopic analyses of gas emissions, sampling and geostatistical theory, and the remote sensing derived strata. Surface flux measurements coupled with multitemporal coregistered AVHRR data will provide the basis for an assessment of the seasonal variability of carbon flux for Arctic tundra ecosystems. Various sources of error in the regional-seasonal estimates will be identified and their contribution to the overall estimated precision evaluated. The significance of high latitude ecosystems in the global carbon budget will be addressed through atmospheric modeling using existing photochemical models developed at ARC.

**W93-70360****463-43-07**

Goddard Inst. for Space Studies, New York, NY.  
**PALEOECOLOGICAL STUDIES OF CH<sub>4</sub> EMISSIONS**  
 Dorothy Peteet 212-678-5587

The general objectives are to trace the postglacial development of the present distribution of peat bogs at mid-high latitudes using transects across Alaska, Canada, and the major peatland region of the Soviet Union. The relationship between areal extent of peatlands to biogeochemical cycles on a global scale will be made by comparison of the timing of subarctic peatland formation in these regions with the timing of natural variations in atmospheric methane concentrations from ice core data. High latitudes not only are thought to play a role in driving climate change, but are sensitive reflectors of change at present. The relationship of peatland formation to climate change will be determined by comparing the peatland stratigraphy and chronology with independent glacial history of these regions and palynological and macrofossil data in the sediment cores. Peatland sections from coastal Alaska (1989), inland Alaska (1990), and coastal western Siberia (1992) are presently being analyzed for macrofossils and submitted for precise C-14 chronology. The 1992-93 field research will expand this objective to Canada and the USSR.

**W93-70361****463-61-00**

Ames Research Center, Moffett Field, CA.  
**BIOGEOCHEMICAL RESEARCH IN TROPICAL ECOSYSTEMS: MECHANISMS OF TRACE GAS PRODUCTION**  
 P. A. Matson 415-604-6884  
 (462-43-00)

The objective of this research is to quantify fluxes of important biogenic gases from tropical ecosystems, and to understand the sources, sinks, and processes that control flux out of the systems. The long-term goal of this project is to establish a geographic perspective on trace gas flux and biogeochemical processes in tropical environments. This encompasses measurement of gas fluxes from soil and vegetation and estimation of their regional and global budgets. The approach is to measure emissions of nitrous oxide, nitric oxide, methane, carbon dioxide, and other gases in a range of ecosystems representing gradients of climate, fertility, and disturbance. Studies along such gradients will improve understanding of the factors that control flux, and will provide the basis for developing models that predict flux. Such models, driven by variables such as land use type, climate-moisture characteristics, and canopy characteristics, will be tied to remote sensing techniques for extrapolation to regional and global scales.

**W93-70362****463-67-00**

Langley Research Center, Hampton, VA.  
**BIOSPHERIC/ATMOSPHERIC INTERACTIONS**  
 W. R. Hook 804-864-6055

The Global Biomass Burning and Biogenic Gases Program is a field measurement program to quantify: particulate and gaseous emissions from biomass burning; pre- and post-burn biogenic gas emissions; and the global/areal extent of biomass burning from satellite images. The Wetlands Project will establish relationships between CO<sub>2</sub> exchange and remote sensing parameters in

wetlands vegetation photosynthesis and corresponding canopy reflectance characteristics.

**W93-70363 463-67-00**

Ames Research Center, Moffett Field, CA.  
**BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS**

M. A. Spanner 415-604-3620  
 (462-43-00)

The objectives of these projects are to model the processes of carbon, nitrogen, and water cycling through temperate coniferous forests and to examine the effects of disturbance on these processes. The approach is to test an existing ecosystem model of carbon, nitrogen, and water fluxes using a database derived from a combination of field and remote sensing studies from optothermal transient emission radiometry (OTTER). The database developed from the OTTER data will be used to drive models over large geographic regions, provide tests of spatial subsampling and scaling, and assess land disturbance effects.

**W93-70364 463-75-63**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AVIRIS OPERATIONS**

R. O. Green 818-354-9136  
 (465-65-01; 665-81-08)

The objective is to support the activities required to acquire, calibrate and distribute data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) for NASA sponsored science investigators in fiscal year 1993. AVIRIS measures the total upwelling radiance incident at the sensor in 224 channels with nominally 10 nm spectral sampling and 10 nm spectral response functions (FWHM) from 400 to 2500 nm in the electromagnetic spectrum. Data from these channels are acquired at nominally 20 by 20 m spatial resolution with an 11 km by up to 100 km image extent. All distributed AVIRIS data are calibrated with respect to spectral, radiometric and geometric characteristics. A brief summary of the AVIRIS operations assumptions for fiscal year 1993 are as follows: (1) Routine and preventative maintenance will be undertaken such that no degradation in performance occurs; (2) For 6 contiguous months AVIRIS will be at JPL for preventative maintenance and refurbishment following the 1992 flight season; (3) The following data acquisition deployments away from JPL will be supported (a) 14 weeks at Moffett Field, CA, and (b) two 3-week deployments to Wallops Island, VA; (4) Up to 1000 calibrated AVIRIS scenes will be distributed to sponsored investigators; and (5) Cost estimates for transportation of AVIRIS and travel to support launch site operations are based upon FY-92 travel and shipping costs. The objectives will be fulfilled through the following activities at JPL: (1) AVIRIS task and RTOP management; (2) calibration and validation science; (3) experiment coordination and mission planning; (4) data decommutation, calibration and distribution; and (5) sensor operations, calibration and maintenance.

## Atmospheric Processes

**W93-70365 464-11-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**OZONE MEASUREMENTS**

J. J. Margitan 818-354-2170

Vertical profiles of ozone in the stratosphere will be measured by a dual channel UV photometer flown as part of research balloon flights. Ozone profiles will be obtained on ascent and descent with 1 second (better than 100 meters) resolution. These data will serve as a comparison to other in situ and remote sensing techniques. This research effort is a collaborative project with the NOAA Aeronomy Laboratory. The ozone data will be useful in

improving our understanding of stratospheric chemistry, and in particular in assessing the degree of discrepancy between measurements and calculations of ozone near 40 km. Ozone measurements will also be made aboard NASA's high altitude research aircraft. This research will be a part of the UARS (Upper Atmosphere Research Satellite) Correlative Measurements Program.

**W93-70366 464-11-07**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**LASER DIODE SENSOR**

C. R. Webster 818-354-7478

The Balloon-Borne Laser In-Situ Sensor (BLISS) and Aircraft Laser Infrared Absorption Spectrometer (ALIAS) tasks have as their primary objective the collection of reliable data on the concentrations, distributions, and variabilities of the minor and trace species in the stratosphere. These data are to be used by modelers and dynamicists to assess and predict the effects of change in the chemical content of the upper atmosphere due to anthropogenic activity. The BLISS instrument uses tunable diode lasers (TDL's) to measure the absorption due to selected species between the balloon gondola and a lowered retroreflector which defines up to a 1-km absorption path. The TDL beam in use is stabilized onto the lowered retroreflector by use of an optical tracking system. Several species can be measured simultaneously to the 0.1 ppbv level in sensitivity, throughout a diurnal cycle, and with the additional possibility of altitude profiling. The current measurement capability includes NO, NO<sub>2</sub>, O<sub>3</sub>, HNO<sub>3</sub>, HCl, H<sub>2</sub>O, CH<sub>4</sub>, N<sub>2</sub>O, CO<sub>2</sub>, and minor gas isotopes. A compact version of this instrument has been designed and built, and has recently flown on the ER-2 aircraft as part of the 1991/92 AASE-II campaign out of Alaska and Maine, during which ALIAS provided sub-part-per-billion sensitivity measurements of HCl, CH<sub>4</sub>, and N<sub>2</sub>O. The ALIAS instrument employs a multipass gas cell with measurement capability for NO<sub>2</sub>, N<sub>2</sub>O, HCl, CH<sub>4</sub>, H<sub>2</sub>O, and HNO<sub>3</sub>.

**W93-70367 464-12-00**

Ames Research Center, Moffett Field, CA.

**AIRBORNE IR SPECTROMETRY**

S. Wegener 415-604-6278

The objective is to obtain information on the spatial and temporal distribution of stratospheric constituents for use in testing current theories of stratospheric chemistry, especially ozone depletion. The approach is to deploy infrared (IR) absorption and emission spectrometers on balloons, aircraft, and selected ground observations in coordination with other experimenters in order to identify constituents and infer concentrations from spectra obtained.

**W93-70368 464-12-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**IR SOLAR ABSORPTION SPECTRA**

G. C. Toon 818-354-8259

(464-16-01)

The objective is to obtain high resolution near-infrared solar spectra from which the abundance of many atmospheric minor constituents can be quantified. From these spectra, recorded at different latitudes in both hemispheres and at different seasons, the abundance of over 30 different gases can be measured simultaneously. These spectra also form a historical archive of the state of the atmosphere and will be re-analyzed as improved spectral parameters and retrieval software become available. Analyses of the data obtained from the measurements made in the course of this research meet the objective of establishing the present compositional state of the atmosphere. On a yearly basis retrieved gas abundances are compared with previous measurements in order to evaluate trends, and also with computer model predictions in order to assess their accuracy. Particular emphasis is being placed on chemical processes of current international interest, such as the depletion of the ozone layer. The approach taken to meet the science objective is to measure the spectral absorption of solar radiation by the atmosphere over the entire 2 to 16 microns spectral region using a Fourier Transform

Spectrometer, the JPL MARK IV Balloon Interferometer. Measurements have been and will continue to be made from various platforms including stratospheric research balloons, aircraft, and ground-based sites at locations of widely varying latitudes such as the Arctic, the tropics, and the Antarctic regions.

**W93-70369 464-12-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MM AND SUB-MM RADIOMETRY**

R. A. Stachnik 818-354-1921

(464-16-01)

The objective is to improve understanding of Earth's upper atmosphere by balloon-based microwave measurements at millimeter and submillimeter wavelengths. Well-founded concerns that man's technological activities may perturb upper atmospheric balances, particularly those maintaining stratospheric ozone, justify this objective. The general approach is to first determine which measurements are needed for atmospheric research and perform calculations to define which subset of these can be usefully performed by microwave techniques. A field program is then established for those measurements of sufficient value. The field program may involve instrument development or improvement. One important goal of this program is to determine both the capabilities and limitations of microwave techniques so they can be used efficiently in NASA's overall Upper Atmosphere Research Program.

**W93-70370 464-12-15**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**FAR INFRARED BALLOON RADIOMETER FOR OH**

H. M. Pickett 818-354-6861

A high resolution radiometer will be employed for stratospheric balloon observations of the hydroxyl radical in the far infrared region. The instrument uses three Fabry-Perot resonators to resolve stratospheric limb emission of OH at 101 cm(exp -1) (99 microns). The resolution is 0.0017 cm(exp -1) to match the width of the stratospheric emission lines. The instrument has the sensitivity for retrieving useful OH mixing ratio profiles between 25 km and 46 km with 3 km vertical resolution. Column density of OH above 46 km is also retrieved. The instrument is compact (0.36 cu m), light-weight (100 kg), and requires low power (45 W) and thus is well-suited to balloon observations.

**W93-70371 464-13-15**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**NDSC DIFFERENTIAL ABSORPTION LIDAR**

I. S. McDermid 619-249-4262

The primary objective is to provide long-term records of the atmospheric ozone concentration and temperature profiles from both the facility already established at JPL's Table Mountain Facility in Southern California and from the new Network for the Detection of Stratospheric Change (NDSC) facility to be established at Mauna Loa Observatory in Hawaii. These measurements, which will become part of the NDSC database, will aid in the detection of changes in the ozone profile and provide information to help understand such changes. In the short term, these lidars are participating in the Correlative Measurements Program for the Upper Atmosphere Research Satellite (UARS) by making comparative, ground-truth, ozone, and temperature measurements for the UARS instruments that also measure these profiles. Since the eruption of Mt. Pinatubo in Jun. 1991, extensive data on the volcanic aerosols in the stratosphere have also been obtained. The approach used to measure ozone profiles is that of differential absorption lidar (DIAL) which uses two laser wavelengths to probe the atmosphere. For stratospheric measurements high laser energies are required and these are provided by a xenon chloride excimer laser that operates at 308 nm. Raman shifting of the excimer laser gives the reference wavelength at 353 nm which is also used in the temperature measurement. Two telescopes of 90 and 100 cm aperture are used to collect the laser radiation backscattered from the atmosphere for the TMF and MLO systems. The stratospheric ozone lidar at TMF has been in routine operation since 1988 and has made more than 450 independent ozone

profile measurements. This system has also participated in a number of intercomparison campaigns, culminating in the extremely successful 1989 STÖIC campaign, which have proved the quality of the results from this lidar. During the last two years, a new stratospheric ozone lidar has been under development for inclusion in this program at Mauna Loa. This system will be in full operation in FY-93. The program goals for FY-93 are: (1) to continue to make measurements of ozone and temperature profiles on a regular and frequent basis at TMF; (2) to complete the installation of the new stratospheric ozone lidar at Mauna Loa and to commence a measurement program similar to that at TMF; (3) to use all of the lidars to participate in the UARS Correlative Measurements Program; and (4) to continue to participate in intercomparisons and other developmental activities in support of the NDSC.

**W93-70372 464-13-22**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**NDSC MICROWAVE INSTRUMENT SUPPORT**

I. S. McDermid 619-249-4262

The objective of this task is to continue to support the operation of the Network for the Detection of Stratospheric Change (NDSC) microwave radiometers for routine measurements of stratospheric ozone and water vapor profiles. A 100 GHz ozone radiometer, developed by Millitech Corporation for the NDSC, was installed at TMF in June 1989. The Principal investigators for this instrument are Alan Parish, of Millitech and the University of Massachusetts, and Brian Connor of NASA LaRC. The millimeter-wave ozone instrument consists of a cryogenically cooled, single sideband, heterodyne radiometer, tuned to 110 GHz, and a multi-channel filter spectrometer. A second microwave radiometer, for measurements of water vapor, was developed by the Naval Research Laboratory and was installed at TMF in June 1991. The Principal Investigator for this instrument is Richard Bevilacqua of NRL. The water vapor instrument consists of a cryogenically cooled 22 GHz radiometer and multi-channel filter spectrometer. The TMF facility provides an all-weather, year-round, 24-hour per day operating site with provisions for on-site weather monitoring and archiving, and automated data transfer between TMF and the principal investigators. Daily calibrations and routine maintenance are carried out by JPL personnel 7 days a week. It is proposed that these instruments will eventually be relocated at the NDSC station at Mauna Loa, Hawaii. Since there will also be a JPL lidar at this station, it will be possible to continue the same level of support for the microwave instruments at the new location.

**W93-70373 464-14-00**

Ames Research Center, Moffett Field, CA.

**STRATOSPHERIC PROCESSES AND ATMOSPHERIC CHEMISTRY STUDIES**

P. B. Russell 415-604-5404

The objective is to increase knowledge of the stratosphere and its exchange with the troposphere, with particular emphasis on processes related to ozone depletion. The approach is to develop advanced instrumentation for high- and medium-altitude aircraft (e.g., ER-2, DC-8) and balloons; design and develop special platforms, as appropriate; design and fly missions that acquire data on phenomena of interest; and use the data to answer questions of current scientific concern. The measurements encompass stratospheric chemistry, physics, and dynamics. This RTOP includes four field campaigns now in the data analysis stage, one campaign in the planning and execution stage, and possible future campaigns. Names, aircraft, locations, field dates, and goals include: (1) Stratosphere-Troposphere Exchange Project (STEP) (U-2 and ER-2, US and Australia, 1984-87, to improve understanding of processes controlling transport across the tropopause and toward the ozone layer); (2) Airborne Antarctic Ozone Experiment (AAOE) (ER-2 and DC-8, Chile and Antarctica, August and September 1987, to explain the cause of the Antarctic ozone hole); (3) Airborne Arctic Stratospheric Expedition (AASE) (ER-2 and DC-8, Norway and the Arctic, January to February 1989, to study the northern polar stratospheric clouds and ozone depletions); (4) AASE 2 (ER-2 and DC-8, Alaska, Maine, Norway and the Arctic, October 1991 to April 1992, to improve



understanding of heterogeneous radical chemistry and dynamics associated with ozone loss); and (5) AAOE-2 (ER-2 and DC-8, New Zealand, Chile and Antarctica, April to September 1994, to study Antarctic ozone depletion).

**W93-70374** 464-14-20  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**MICROWAVE TEMPERATURE PROFILER**  
B. L. Gary 818-354-3198

The proposed work consists of two parts: (1) analysis of data taken with JPL's Microwave Temperature Profiler (MTP) instruments (MTP/ER2 and MTP/DC8) when they flew on NASA's ER-2 and DC-8 aircraft during the AASE-II (Airborne Arctic Stratospheric Expedition II); and (2) training of a new employee in the 'art' of the MTP/ER2 and MTP/DC8 instruments and data analysis. The MTP-derived temperature fields will be used to study atmospheric dynamic phenomena related to polar ozone depletion. The new employee will be trained so that during the following year it will be more feasible to participate in the ASHOM (Airborne Southern Hemisphere Ozone Mission). The MTP instruments are airborne passive microwave radiometers that make scans of 'brightness temperature' versus elevation angle, which are converted to profiles of air temperature versus altitude. The altitude temperature profiles are used to infer which altitudes are cold enough to produce polar stratospheric clouds. The altitudes of isentropic surfaces are calculated and presented as 'isentropic altitude curtain cross-sections'. These cross-sections are then studied for the presence of various dynamical meteorological processes, such as 'gravity wave' altitude oscillations of air parcels.

**W93-70375** 464-16-01  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**MULTI-SENSOR BALLOON MEASUREMENTS**  
O. F. Raper 818-354-2435  
(464-12-05; 464-12-06)

Continuing technical, logistical, and operational support of stratospheric balloon flights is provided to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. Four modular gondola systems can carry multi-instrument packages consisting of several JPL remote sensing instruments, and instruments from other institutions in the U.S. or abroad, configured for a particular scientific purpose. Data obtained on the altitude profiles for a number of chemically coupled species from one or simultaneous flights in the same air mass is used for instrument intercomparison purposes and for the validation of atmospheric chemical models.

**W93-70376** 464-21-02  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**CHEMICAL KINETICS OF THE STRATOSPHERE**  
L. F. Keyser 818-354-3234

A program is underway to determine rate constants and product yields of atmospheric reactions by laboratory kinetics and photochemical techniques, to develop new experimental methods to detect reactive species under conditions of temperature and pressure occurring in the atmosphere, and to study the physical-chemical properties of atmospheric aerosol surfaces. These studies will be carried out by using a discharge-flow resonance fluorescence system interfaced with infrared diode-laser spectrometry and mass spectrometry. Aerosol surfaces will be studied by using infrared spectrometry, gas-absorption analysis, and scanning electron microscopy.

**W93-70377** 464-21-05  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**HOMOGENEOUS AND HETEROGENEOUS PROCESSES OF ATMOSPHERIC INTEREST**  
M. T. Leu 818-354-2432

The purpose of this research is to obtain direct measurements of kinetic rate parameters for homogeneous and heterogeneous reactions important in stratospheric chemistry, and to develop new

experimental techniques for laboratory study of polar ozone chemistry.

**W93-70378** 464-21-06  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**KINETICS OF TROPOSPHERIC AND STRATOSPHERIC REACTIONS**  
S. P. Sander 818-354-2625  
(464-53-01)

A program of laboratory studies is underway to measure kinetic, photochemical, and spectroscopic parameters relevant to tropospheric and stratospheric chemistry. Attention will be focused on reactions important in polar ozone chemistry. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis, discharge flow-mass spectrometry, and discharge flow-Fourier transform infrared spectroscopy. Part of this effort will include the continued development of a Fourier transform ultraviolet spectrometer for laboratory and field use.

**W93-70379** 464-22-01  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE**  
W. B. DeMore 818-354-2436

The objective is to conduct laboratory studies of stratospheric photochemistry, including photolytic quantum yields, reaction rates and mechanisms, product distributions, and absorption cross sections.

**W93-70380** 464-23-00  
Ames Research Center, Moffett Field, CA.  
**QUANTITATIVE INFRARED SPECTROSCOPY OF MINOR CONSTITUENTS OF THE EARTH'S STRATOSPHERE**  
C. Chackerian, Jr. 415-604-6300

Remote and in situ detection and measurement of stratospheric minor constituent species via spectroscopic techniques are being routinely employed to develop a better understanding of this portion of our atmosphere and man's effect upon it. Proper interpretation of these measurements relies strongly on having the correct molecular parameters. The objective of this work is to obtain laboratory measurements of basic molecular parameters, such as rovibrational line intensities and half-widths, absorption band intensities, vibrational and rotational constants, vibration-rotation interaction constants, and line position measurements including pressure induced shifts, as well as to develop new spectroscopic techniques to detect species in question. These parameters, and their dependence on pressure and temperature, will be determined from spectra obtained by using cooled cells, long path gas cells, high resolution interferometers, and tunable diode laser spectrometers. At Laboratoire d'Infrarouge various experimental techniques and new theoretical approaches are being used to obtain and interpret infrared spectra of free radical molecules. Also, in collaboration with Stanford University, the sensitivity of magnetic circular dichroism will be tested for in situ detection of the OH radical via the A to X transition. A prototype detector for free radicals, based on the technique of infrared magnetic rotation spectroscopy, is being constructed.

**W93-70381** 464-23-08  
Jet Propulsion Lab., California Inst. of Tech., Pasadena.  
**INFRARED LABORATORY SPECTROSCOPY IN SUPPORT OF STRATOSPHERIC MEASUREMENTS**  
R. A. Toth 818-354-6860

For the proposed task, high resolution infrared laboratory spectra of stratospheric molecules will be recorded and analyzed to produce line lists of molecular parameters (line frequencies, strengths, widths, and lower state energies). The molecules studied will be those minor and trace species of importance in understanding the Earth's atmosphere. The particular spectral regions to be analyzed (2 to 16 microns) coincide with those used by NASA field experiments that do remote sensing by high resolution spectroscopy (ATMOS, BLISS, Mark IV, UARS, EOS, and the ground-based network). The laboratory spectra will be recorded at spectral resolutions of 0.0028/cm, 0.0056/cm, and



0.011/cm with a Fourier transform spectrometer located at Kitt Peak National Observatory. Data reduction and measurement will be performed on the ATMOS Data Analysis Facility at the Jet Propulsion Laboratory (JPL), and modeling of the measurements by quantum mechanics will be done at JPL and elsewhere in collaboration with non-JPL colleagues. Emphasis will be placed on high accuracies for the line frequencies, line strengths, line widths and shifts, and on comprehensive analyses of important spectral regions to provide complete spectral information for atmospheric remote sensing.

**W93-70382****464-23-09**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**LASER LABORATORY SPECTROSCOPY**

R. D. May 818-354-3256

The Laser Laboratory Spectroscopy Program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements made using infrared spectroscopy, specifically by the Balloon-Borne Laser In-Situ Sensor (BLISS) infrared laser instrument, the Aircraft Laser In-Situ Absorption Spectrometer (ALIAS), and also the Mark IV, and ATMOS FTIR spectrometers. Line positions, absorption strengths, and air-broadening coefficients are the spectral parameters measured, including their dependence on temperature. New spectroscopic techniques for sensitivity enhancement and spectral lineshape analysis are also investigated.

**W93-70383****464-23-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MILLIMETER AND SUBMILLIMETER SPECTROSCOPY IN SUPPORT OF UPPER ATMOSPHERIC RESEARCH**

E. A. Cohen 818-354-4701

A program of millimeter and submillimeter spectroscopy research will be conducted in support of upper atmospheric research. This will include laboratory studies and generation of spectral line lists. These will be made available for distribution to the field measurement community via the Jet Propulsion Laboratory (JPL) Microwave Millimeter and Submillimeter Spectral Line Catalog. The program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the JPL millimeter radiometer instruments. Emphasis is placed on accuracy of line frequency, line width, and transition moment measurements, in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements. This will be cataloged in a continuously upgraded millimeter data base and made available to interested users. This program has provided valuable molecular structural information which has direct bearing on proposed mechanisms for polar ozone destruction. The techniques employed have been shown to be uniquely capable of identifying products of ClO reactions. Work in this area will continue with particular emphasis on elucidating the role of the higher chlorine oxides, oxyacids, and transient species in upper atmospheric chemistry.

**W93-70384****464-34-00**

Ames Research Center, Moffett Field, CA.

**LOWER STRATOSPHERE AIRCRAFT DATA ANALYSIS**

L. Pfister 415-604-3183

The purpose of this research is to address several long-standing topics in the dynamics and chemistry of the lower stratosphere, including: (1) tropical and midlatitude stratosphere-troposphere exchange; (2) the stratospheric water budget; and (3) transport within the lower stratosphere. Scientific questions about the following topics will be addressed: (1) the respective roles which tropical convection and regional ascent play in the mass input into the tropical stratosphere; (2) implications for the stratospheric water budget; (3) the importance of gravity waves and turbulence to lower stratosphere transport and

momentum budgets; and (4) the importance of short vertical scale phenomena to lower stratosphere latitudinal transport. The tasks under this RTOP will address these issues by analysis and modeling of high-altitude aircraft measurements taken during a number of recent campaigns, primarily the Stratosphere-Troposphere Exchange Project campaign of 1987, the Airborne Antarctic Ozone Experiment of 1987, the Airborne Arctic Stratosphere Expedition (AASE) of 1989, and AASE 2 of 1992. Measurements include meteorological variables, ozone, nitrogen oxides, water vapor, total water, particle data, carbon monoxide, nitrous oxide, cosmogenic radionuclides, and chlorine and bromine compounds. Auxiliary data (radiosondes, satellite measurements) will also be employed.

**W93-70385****464-41-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**DATA SURVEY AND EVALUATION**

W. B. DeMore 818-354-2436

An up-to-date tabulation and critical evaluation of kinetic and photochemical data relevant to the stratosphere will be maintained for use by atmospheric modelers, to aid in the establishment of research priorities, and to identify gaps or inconsistencies in the database.

**W93-70386****464-53-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**KINETIC STUDIES OF TROPOSPHERIC FREE RADICALS**

S. P. Sander 818-354-2625

(464-21-06)

A program of laboratory studies is underway to measure kinetic and photochemical parameters involving key free radical reactions in tropospheric chemistry. Attention will be focused on reactions involved in methane oxidation cycle, and the homogeneous mechanisms for the oxidation of non-methane hydrocarbons including isoprene and the terpenes. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis, discharge flow-mass spectroscopy, and discharge flow-FTIR spectroscopy.

**W93-70387****464-54-00**

Ames Research Center, Moffett Field, CA.

**GLOBAL TROPOSPHERIC EXPERIMENT AIRCRAFT, MEASUREMENTS**

H. B. Singh 415-604-6769

The objective of this program is to provide atmospheric measurements aboard NASA aircraft to support the science goals of the Global Tropospheric Experiment. The approach is to develop and test airborne instrumentation; integrate it on the aircraft platforms (Electra, DC-8); operate it during Global Tropospheric Experiment flights; provide data as required by Global Tropospheric Experiment project office; and analyze, interpret, and publish individual and/or collaborative results.

## Solid Earth Processes

**W93-70388****465-12-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**CRUSTAL STRAIN MODELING USING FINITE ELEMENT METHODS**

G. A. Lyzenga 818-354-6920

The objectives of this RTOP are the application and interpretation of numerical models of the time dependent deformation of the earth's crust in active tectonic zones. This research has direct relevance to the interpretation of measurements being carried out in conjunction with the NASA Geodynamics program. As a scientific investigation, this modeling effort is aimed at answering questions raised by both geodetic and other observations concerning the state of crustal stress and driving

forces at plate tectonic boundaries. In this way, the task serves as a theoretical and interpretive complement to the observational information provided by space geodesy. Although the problem of understanding plate tectonic deformation processes is limited by the availability of data, there exist considerable theoretical uncertainties concerning the fundamental physics and distribution of constitutive properties and stresses. The task described in the present RTOP addresses the underlying physical processes giving rise to the observed motions. The approach employed in this task uses the finite element method to construct time dependent models of tectonic deformation in spatially inhomogeneous domains. This approach allows the description of realistic configurations of faults and variable material properties that are not amenable to analytic techniques. These modeling methods have proven useful for gaining insight into the physical processes driving and controlling episodic and steady deformation at plate boundaries. Continuing research employing these techniques have been successful in addressing the dual problems of crustal stress state and surface deformation fields. The continuation of this work will be aimed specifically at the problems of stress and strain accumulation in blind thrust and related reverse faulting geometries.

**W93-70389****465-12-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MODELING OF CONVERGENT PLATE MARGIN DEFORMATION**

P. R. Lundgren 818-354-1795

The objectives of this RTOP are as follows: (1) to determine the plate margin kinematics and deformation of northwestern South America and adjacent plates; (2) to assess seismic strain accumulation versus steady slip deformation models with the plate margin kinematics and deformation models for Alaska; and (3) to understand the role of oblique convergence on plate margin deformation in northwestern South America, Sumatra, the Southwest Pacific, and Alaska. The approach of this RTOP will be as follows: (1) to use a joint, weighted least squares inversion of geologic and Central and South America (CASA) GPS baseline data, in a finite element formalism to obtain the velocity field and strain deformation in northwest South America; (2) to compare the Very Long Baseline Interferometry (VLBI) and Global Positioning System (GPS) geodetic measurements for Alaska with kinematic deformation models, and with earthquake strain accumulation models; and (3) to extend application of the inversion method to obliquely convergent subduction zones in Sumatra, New Guinea, and the Southwest Pacific, where space geodetic results exist, to model their deformation, and compare these models with oblique convergence deformation in South America and Alaska.

**W93-70390****465-13-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**DYNAMICS OF NORTH AMERICAN-PACIFIC SHEAR**

E. R. Ivins 818-354-4785

The objective of this RTOP will be to constrain deformation models along the western boundary of North America by modeling analysis of fault structure, seismicity patterns, sub-crustal structure, and geodetic data. There are five parts to the proposed work of this RTOP. The first part is the model treatment of the crustal structure beneath the western Transverse Ranges. Included are complexities of all fault senses of motion (dextral, sinistral, reverse, etc.). The second part is the application of the analytic method of aseismic creeping motion to a buried thrust-strike slip fault south of the Big Pine fault and north of the Santa Cruz Island fault to determine the upper bound on compressional strain accommodation. The third part is to apply semi-analytical analysis to three-dimensional ductile flow beneath the North American Pacific boundary. The fourth part is to assess the use of astroazimuth Very Long Baseline Interferometry (VLBI) observations and Global Positioning System (GPS) data to constrain regional block rotations. The fifth part is to use assumed rates of motion at depth and develop self-consistent stress transfer models that match known crustal deformation rates.

**W93-70391****465-13-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GPS STRAIN MONITORING IN THE NEW MADRID SEISMIC ZONE**

D. M. Tralli 818-354-1835

Large earthquakes in the New Madrid seismic zone (Missouri, Arkansas, Illinois, Kentucky, and Tennessee), such as the great 1811-12 earthquakes, pose a serious hazard to the central U.S. The magnitude, moments, and fault geometry of these events were inferred using isoseismal data. However, the locations and mechanisms of more recent earthquakes were used to delineate the seismic zone and to analyze the faulting in the larger post-1960 events. Earthquake recurrence and probability estimates were derived from historic magnitude-recurrence data. The absence of recent large earthquakes poses difficulties: mechanisms are available only for events with  $m(\text{sub } b)$  less than or equal to 5.0, and the recurrence estimates for events with  $m(\text{sub } b)$  greater than or equal to 6.4 require significant extrapolations. The seismic zone overlies the Reelfoot rift, a Precambrian to Early Cambrian rift system buried by thick Phanerozoic strata and Quaternary alluvium. Recent seismicity appears related to reactivation of fossil rift-related faults by the current stress field. We have initiated a collaborative research program with Northwestern University, the University of Missouri, and the University of South Carolina, using Global Positioning System (GPS) geodesy to quantify the rate and distribution of strain accumulation in the New Madrid seismic zone. We have established and measured a series of geodetic baselines between approximately 25 sites within the New Madrid seismic zone and at more regional distances, with the long-range goal of using bi-annual measurements to determine baseline changes and thus provide quantitative constraints on the regional tectonics, fault zone mechanics, and earthquake recurrence, and for understanding GPS errors such as tropospheric path delays and azimuthal asymmetry, and also assessing regional strain constraints with ROGUE GPS receivers in network.

**W93-70392****465-13-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ACTIVE DEFORMATION IN THE MOJAVE DESERT AND WALKER LANE: A GLOBAL POSITIONING SYSTEM EXPERIMENT**

M. M. Miller 818-354-8820

The objective of this RTOP is to carry out Global Positioning System (GPS) experiments that will monitor fault motions both within the Mojave Desert and between the Mojave Desert and adjacent areas. These studies will: (1) characterize the role of Mojave faulting in accommodating modern Pacific-North American plate motions; (2) establish new constraints on the relation between tectonism the Mojave Desert and adjacent structural domains; and (3) provide local strain nets that will clarify ambiguities of local displacements around NASA's Crustal Dynamics Project MOJAVE and Owens Valley Radio Observatory (OVRO) base stations. Site location, monumentation, and related field work for the regional network and one tectonic footprint network at the MOJAVE base station was conducted in 1991. Both networks were occupied in May 1991. Additional sites and tectonic footprint networks will be added during the remainder of FY-92. In addition, data reduction for the 1991 experiment is currently underway. Reoccupation of the regional network and the first occupations of additional local networks will occur on a biannual basis. Data reduction will occur mostly in the alternate years. Ongoing field studies will focus on characterizing localized deformation detected by Global Positioning System experiments.

**W93-70393****465-13-08**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**PARKFIELD GPS EXPERIMENT**

K. Hurst 818-354-6637

The objectives of this RTOP are as follows: (1) to better determine the slip distribution on the northwestern part of the Parkfield segment of the San Andreas fault before, during, and after the earthquake which is predicted to occur there in the next few years; (2) to prove the accuracy of the Rapid Static Survey

(RSS) Global Positioning System (GPS) technique; (3) to investigate possible sources of systematic error in RSS GPS measurements; and (4) to improve the precision of the vertical baseline component through improved modeling of the troposphere. The approach of this RTOP will be as follows: (1) install a network of geodetic monuments across the fault and extending 30 to 40 km away from the fault; (2) measure and remeasure the network using RSS techniques; (3) make measurements three times the first year, and yearly thereafter until the earthquake occurs, after which time the network would be resurveyed as many times as possible as quickly as possible; and (4) model the resulting station displacements as a function of slip on the fault and/or local effects as appropriate.

**W93-70394****465-14-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL TECTONIC MOTIONS**

R. S. Gross 818-354-4010

The proposed research is intended to continue the study of present day plate motions using Earth orientation measurements, and the related production of Earth orientation series which account for tectonic motions of the participating geodetic observatories. This will be accomplished by the analysis of publicly available Earth orientation data, and the re-reduction of Infrared Interferometer Spectrometer (IRIS), POLARIS, and Crustal Dynamics Project Mark 3 Very Long Base Interferometry (VLBI) data at JPL using JPL software. It should be noted that the inherent accuracy of VLBI baseline orientation determinations can be equal to or better than the length estimates from the same baselines. The study of tectonic motions through orientation measurements will both complement the more traditional study of length changes and serve as an important source of new information, without requiring the acquisition of any additional data. The first task will involve the re-reduction of the IRIS/POLARIS and Crustal Dynamics Project Mark 3 VLBI data with an independent JPL software package providing both the length and orientation determinations. The length and orientation of each baseline in the network will be estimated each time it is observed to provide the detailed geodetic results necessary for a complete analysis of network deformation. This will produce determinations of the velocity of relative motions between Europe and America with formal errors of 1 centimeter/year or smaller from both orientation and length data and will greatly increase the confidence in rate estimates from changes in baseline length. Publicly available Earth orientation measurements (Satellite Laser Ranging (SLR), Lunar Laser Ranging, and VLBI from other sources - NASA Crustal Dynamics Project and the Deep Space Network) together with baseline orientation results from the above re-reduction of the IRIS/POLARIS and Crustal Dynamics Project Mark 3 VLBI data, will be used to study the slow divergences in the observed Earth orientation caused by plate motions. In this manner, tectonic motion estimates with formal errors of 1 to 2 centimeters/year or smaller from locations on the North American, European, and Australian plates will be produced. The resulting drift rate estimates will be compared with geological plate motion models and with other geodetic motion estimates.

**W93-70395****465-14-07**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**KINEMATIC MODELS COMBINING VLBI, GPS, AND TRILATERATION DATA AND PLATE CONSTRAINTS**

D. F. Argus 818-354-3380

We aim to combine geodetic measurements from Very Long Baseline Interferometry (VLBI), the Global Positioning System (GPS), Satellite Laser Ranging (SLR), and trilateration and use the geometric rigor of rigidity in the plate tectonic model to construct kinematic models of crustal deformation. We aim also to apply these models to outstanding tectonic problems, focusing on the relation between motions of plates, deformation of crust lying adjacent to plates, and geologic phenomena like faults, earthquakes, and mountains. First, rates of change of components of vectors observed with VLBI, GPS, SLR, and trilateration will be inverted; velocities of plates and velocities relative to plates of

points in deformation belts will be simultaneously estimated. Estimating velocities of points in deformation belts relative to plates will eliminate ambiguities about reference frame, will result in the automatic application of plate requirements, and will allow deformation to be interpreted in frameworks fixed to plates. Second, vector components (or cartesian coordinates) of sites observed with the four geodetic techniques will be inverted; velocities of plates, velocities relative to plates of points in deformation belts, displacements during earthquakes, and velocity gradient tensors of deformation belts will be simultaneously estimated. Simultaneously inverting VLBI and GPS data will eliminate the practice of assuming 'fiducial' locations are absolutely known when GPS data are analyzed.

**W93-70396****465-14-09**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GPS/VLBI VERTICAL MEASUREMENT**

G. Blewitt 818-354-7514

There are three objectives for this RTOP. The first objective is to investigate improvements in vertical geodetic accuracy for the Global Positioning System (GPS) and Very Long Baseline Interferometry (VLBI) in a controlled Research and Development experiment with collocated and concurrent measurements. An additional part of the objective is to improve GPS and VLBI tropospheric models. The second objective is to compare VLBI and GPS solutions for long baselines over an extended period of time, resolve differences, and understand correlations in variations of site position. The third objective is to identify atmospheric conditions likely to give the most unreliable VLBI and GPS geodetic results. The approach of this RTOP contains five parts. The first part is to analyze concurrent GPS data and data from NASA Research and Development VLBI experiments once per month using sites at Kauai, Fairbanks, Mojave, Haystack, Los Alamos, and Wettzell (and perhaps others). VLBI data will be analyzed by co-investigators on the proposal (to NRA-90-OSSA-24) at Harvard Smithsonian and Haystack Observatory. The second part is to process the GPS data in the several day window around the VLBI experiments in order to gather atmospheric statistics and use GPS to attempt to identify conditions leading to anomalous VLBI estimates. The third part is to use auxiliary meteorological information (weather maps, local surface data, radiosondes, etc.) where available to help identify 'hazardous' conditions. The fourth part is to investigate correlations in variations of GPS and VLBI baseline estimates. The fifth part is to develop improvements to atmospheric propagation delay models, utilizing auxiliary data, and exploiting the synergy of GPS and VLBI.

**W93-70397****465-14-11**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**NORTH AMERICAN FIDUCIAL NETWORK**

G. Blewitt 818-354-7514

There are five objectives in this RTOP. The first objective is to establish a major portion of the space geodetic component of the Fiducial Laboratory for an International Natural Science Network (FLINN) laboratories in the U.S., collocating permanent Global Positioning System (GPS) receiving systems at major Very Long Baseline Interferometry (VLBI) sites. The second objective is to analyze a GPS geodetic fiducial network with VLBI-inferred, new millimeter-level reference frame control in North America in support of geodynamics studies. The third objective is to estimate fiducial coordinates of GPS receivers as a function of time and make data available such that other investigators can remove reference frame ambiguity from their regional strain networks. The fourth objective is to monitor and study inter- and intra-plate motions on a continental scale so as to provide a frame within which other, more regional studies can be better interpreted. The fifth objective is to compare and combine results of GPS and VLBI analysis streams for quality control, to enhance solution strength, and to understand sensitivity to modeling assumptions, and to improve modeling and estimation schemes where appropriate. The approach of this RTOP consists of three parts. The first part is to select new GPS sites to be installed and operated by NASA under the DOSE (Dynamics of the Solid Earth) program. GPS sites will be

at existing VLBI facilities of geophysical interest, or established geodetic stability, and with a wide distribution over the U.S. New sites may include Los Alamos, N. Liberty, Ft. Davis, St. Croix, Brewster, Mauna Kea, Hancock, and Kitt Peak. The second part is to retrieve data from DOSE operations, and perform analysis of network GPS data. VLBI data will be analyzed by collaborators at Goddard Space Flight Center. The third part is to perform GPS/VLBI solution intercomparisons and error analyses, assess accuracy, adjust models as appropriate, evaluate site-tie errors, and annually publish fiducial coordinates and site velocities.

**W93-70398****465-15-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**THEORY OF GEODETIC TRANSFORMATIONS**

J. G. Williams 818-354-6466

Several of the mathematical models which govern the transformations between celestial and terrestrial coordinates were developed more than a decade ago. These transformations are used in the reduction of data by all techniques (interferometric or range, laser or radio). The improvements in observational accuracy and data span require the highest accuracy in the models. The assumptions and approximations which these models depend on should be re-evaluated and the models should be improved where needed. Two subjects were picked for initial study and a third has been added. First, the equation of equinoxes has been developed to second order to replace the first-order expression. The dynamical evaluation is done, however, the geometrical interpretation deserves further work. Second, the adopted expressions for precession and obliquity changes with time do not take into account that the average lunar torque is not quite aligned with the average solar torque. This correction is important (estimate 0.2 mas/yr) and should be made. Third, the tidally-driven Universal Time (UT1) variations have been computed from analytical expansions in the past, but they can also be done by numerical Fourier analysis.

**W93-70399****465-16-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**UPPER MANTLE SEISMIC P AND S WAVE STUDY**

D. M. Tralli 818-354-1835

An investigation of the elastic structure of the Earth's upper mantle is sought using global seismic travel-time data (compressional and shear). Global seismic travel-times are tectonically regionalized to estimate velocity functions. Laterally-varying P and S wave velocity inversion results are, in turn, inverted jointly to estimate lateral variations in elastic properties, seismic parameter, density, and Poisson ratio. The results will be used to constrain the interpretation of geoid anomalies, and response of the upper mantle to continental loading. The chemical, phase, and thermal properties of the upper mantle will be imaged, with error bounds, to constrain models of plate interaction and convection. A quadratic programming joint inversion of laterally-varying seismic P and S wave velocities to obtain estimates of elastic parameters with corresponding error bounds, ensuring zero mean anomalies which are consistent with the results of mean Earth models was approached. The results of the study will then be combined with satellite gravity data, and geodetic measurements of plate deformation and uplift, to investigate any correlations with tomographic zones of varying thermal and compositional structure.

**W93-70400****465-17-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GEOPOTENTIAL TEMPORAL VARIATIONS**

J. O. Dickey 818-354-3235

The fundamental objectives of this study are to: (1) use laser range data to Laser Geodynamic Satellite (LAGEOS 1) (and soon to LAGEOS 2), recover the effects of dynamical Earth processes upon the Earth's geopotential, and interpret these results to gain insight into the Earth's internal structure and shape, and processes that can induce changes in the geopotential; and (2) obtain improved estimates for the amplitudes and phases of the tidal terms, and interpret these results to gain insight into the Earth's anelasticity and aspherical structure. The approach includes the

following: (1) modification of a version of GEODYN to obtain temporally varying Stokes coefficients, and exploration of various techniques to accomplish this, such as explicitly obtaining the time-dependent Stokes coefficients, or modeling the effects of the geophysical process on the gravitational field and using GEODYN to search for this modeled effect; (2) use of analytical and numerical models for a variety of geophysical processes in order to both compute the expected effect of these processes upon the geopotential and to interpret the observed temporally varying geopotential results; and (3) the search for correlations between changes in the gravitational field coefficients and changes in the Earth rotation parameters. Any such correlations found will lend greater credence to the time varying geopotential results.

**W93-70401****465-17-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**LATERAL VARIATIONS IN SOLID TIDES**

E. R. Ivins 818-354-4785

We shall develop models of solid tidal deformation which include the effects of lateral variation in mantle density, rigidity, and compressibility. Complex tidal models have been developed that are to be compared with available Lageos 1 and 2 ranging station data and other data. The comparison may provide a new constraint on scaling relations between the elastic constants and seismically determined data on shear wave and compressional wave velocity anomalies. Low frequency, relative to those of seismic free oscillations, could imply that thermally controlled dislocation mechanisms control a viscous component of the deformation. These effects will be incorporated into the modeling effort. We intend to provide maps from which local station corrections to tidal Love numbers can be obtained. Corrections to earth rotation and ocean tidal loading shall also be determined.

**W93-70402****465-27-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SHORT-PERIOD TROPOSPHERIC NOISE IN CONTINUOUS GPS MEASUREMENTS**

D. M. Tralli 818-354-1835

An investigation of the level of short-period tropospheric path delay noise in continuous Global Positioning System (GPS) geodetic measurements is undertaken. A GPS geodetic network yielding measurements with high temporal and spatial resolution can be used as a strain instrument for monitoring crustal deformation. While smaller strain rates associated with regional tectonic processes can be observed by epoch geodetic measurements, problems in fault zone behavior (such as the depth extent of creep), the relationship between creep and rupture, and the distribution of slip on a fault, suggest that continuous monitoring is desirable given the short periods over which deformation signals may be defined and otherwise aliased. These different geodetic sampling intervals are subject to distinct error sources. Therefore, identifying those GPS measurement errors which may obscure short-term deformation signals is important, as is achieving high resolution in order to avoid aliasing. In addition to short-period tropospheric path delay fluctuations, the amplification of potential GPS signal multipath effects in local networks and the contribution to the short-period noise spectrum also must be considered. Temporal power spectral density (PSD) models of GPS measurement noise will be determined using data from the Permanent GPS Geodetic Array (PGGA). The crossover frequency at which GPS measurement noise is less than that in high-quality strainmeter measurements will be determined. Different frequency crossovers and smaller relative noise pass bands will be identified, depending on the shapes of the noise PSD's which are determined by the tradeoff between geodetic sampling interval, strain estimate variance, and the level of correlated short-period tropospheric path delay noise. The short-period effects of GPS signal multipath, particularly its amplification in processing dual-band data over local distances, will also be modeled as a further noise contribution which may obscure the interpretation of tropospheric path delays and strain measurements.

**W93-70403****465-28-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GOLDSTONE DOSE SUPPORT**

J. A. Scheid 818-354-9627

This RTOP is to provide support services at the Goldstone Deep Space Communications Complex (DSCC) for the Goddard Space Flight Center (GSFC) office of the NASA Dynamics of the Solid Earth (DOSE) program. The Mojave Base Station (MBS) has been maintained as a part of the Crustal Dynamics Project (CDP) headquartered at GSFC. The CDP terminated, as scheduled, at the end of calendar 1991. Operation of MBS is being phased out in 1992 as the station prepares for closure. Operation will cease altogether and permanently before the start of FY-93. There will be no staff stationed at this facility in the future; all instruments and furnishings will be removed. However, a minimal level of maintenance must be provided for the protection of the antenna and the building which are NASA property. In addition, the Very Long Baseline Interferometry (VLBI) group of the GSFC DOSE program requests support at a level not to exceed 2 days per month for VLBI experiments at one of the operational Goldstone antennas, probably DSS 13. This function includes the designation of an individual to act as the point-of-contact for the GSFC DOSE office at the Goldstone DSCC. Finally, there is a Doppler Orbitography and Radiopositioning Integrated Satellite (DORIS) beacon at the Mojave Base Station site which will continue to operate and which will support the TOPEX/POSEIDON mission. This is an autonomous instrument, requiring maintenance only on an as-needed basis.

**W93-70404****465-31-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ADVANCED MAGNETOMETER**

E. J. Smith 818-354-2248

The objectives of this RTOP are to: (1) operate the helium magnetometer in a scalar mode and demonstrate that it can meet the requirements of future investigations to study secular changes in planetary magnetic fields and to detect crustal magnetic anomalies; (2) evaluate the sensitivity and accuracy of the magnetometer when operated in the vector mode in strong planetary (Earth-like) magnetic fields and to investigate alternative modes of operation to make vector measurements; (3) optically pump helium using an IR laser rather than a lamp excited by an electrodeless discharge and to evaluate the consequences for the magnetometer performance; (4) investigate the possible use of a solid state semiconductor laser and fiber optics in a space flight magnetometer to transmit the pumping radiation between the electronics and sensor; (5) evaluate the magnetometer performance in a hybrid mode in which it alternates (rapidly) between scalar and vector operation; and (6) evaluate the He nuclear precession magnetometer for possible use in space.

**W93-70405****465-32-06**

Goddard Space Flight Center, Greenbelt, MD.

**GEOLOGICAL INTERPRETATION OF MAGSAT ANOMALY DATA**

Patrick T. Taylor 301-286-5412

The objective of this RTOP is to determine the nature, source depth and petrology of the source of the long and intermediate wavelength magnetic anomalies observed at satellite altitude. All relevant geology and geophysical data bases will be used as an aid in this task. Specific areas of study include the mid-continent of the United States and the shield area of the Arabian Peninsula. The project will continue to develop and refine new methods and techniques for reducing and representing Magsat orbital profiles. This includes new methods for noise reduction, for gridding and plotting data, and for analytical interpretation techniques. These data will be combined with the latest results from the analysis of the magnetic properties of lower crust upper mantle petrologic studies.

**W93-70406****465-35-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ARISTOTELES GPS RECEIVER DEVELOPMENT**

E. S. Davis 818-354-8644

The objectives were to develop a set of requirements, select a conceptual design, and layout the program for acquiring the flight equipment needed to support the scientific objectives of the ARISTOTELES mission. The approach follows our proposal. The Global Positioning System (GPS) Tracking System for ARISTOTELES was submitted to NASA on 10 July 1991 and updated on 18 November 1991 to reflect the ESA decision to extend the project definition phase for one year. The Jet Propulsion Laboratory (JPL) has been developing GPS receivers for precision ground applications for the last decade. The latest in the series of ground receivers developed at JPL are the Rogue and TurboRogue. For the Topographic Ocean Experiment (TOPEX)/POSEIDON mission, JPL contracted with Motorola to develop a flight GPS receiver with similar functional characteristics to the ground receivers and with easily achievable performance specifications. Motorola calls this receiver the 'Monarch'. Two flight qualified Monarchs were delivered to the TOPEX/POSEIDON satellite in the spring of 1991. They will operate as a redundant pair. The TurboRogue was also the basis for the conceptual design of the GPS Geoscience Instrument for the Earth Observing System (EOS). At this point, two salient options exist for developing the flight GPS receiver needed for ARISTOTELES: (1) upgrade the performance of the Monarch, adding Application Specific (AS) capability and correcting design deficiencies that stem from errors in the details of the Application Specific Integrated Circuit (ASIC) logic; and (2) identify a flight qualified microprocessor that allows us to adopt the TurboRogue signal processing architecture, its ASIC design, and software. For each option, the cost for an acceptable level of risk will be estimated, and the performance characterized. From this, a decision on the design concept will be made and the process of acquiring the flight equipment initiated.

**W93-70407****465-41-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ERS-1 RADAR PERMAFROST PENETRATION**

T. G. Farr 818-354-9057

The objectives of the proposed research are to measure C-band and L-band microwave penetration in a variety of natural surfaces in order to better understand the physics of microwave interaction with natural volumes and to support the quantitative interpretation of ERS-1 and JERS-1 image data. A second objective is to detect and map subsurface features in arid regions that relate to past climate changes. Finally, this year, JERS-1 SAR and OPS data will be acquired through NASDA-accepted proposals to support penetration studies and regional mapping and correlation of geomorphic surfaces. Areas of interest will include arid regions (north Africa, southwestern U.S., western China, western South America) and a permafrost region (Alaska). Some of the data for the proposed research will be acquired directly by receivers. A number of SAR images will also be required in order to make use of active transponders, as ancillary data to assist in location of receivers relative to beam center, to assess the uniformity of target conditions, and to make mosaics of several arid regions. Targets will be located in Egypt, Alaska, and the western United States. Coverage of the sites in several seasons will be required. We expect to obtain measurements of C-band and L-band microwave attenuation in soils as a function of soil moisture and structure and in permafrost as a function of season. These data will then be used as input to existing microwave interaction models to improve quantitative interpretation of ERS-1 and JERS-1 SAR images. We will also obtain mosaic coverage of several arid regions to support mapping of surface and subsurface features such as drainages and other indicators of past climatic conditions. A limited number of interferometric pairs and triplets will also be acquired in order to add in the topographic dimension. In Alaska, receivers will be used to make a set of measurements in winter and as thawing occurs in the surface layers in the spring. Summer measurements will be required in the western U.S. As access is

the main factor affecting scheduling in Egypt, one or two extended expeditions will be required to make measurements at that site.

**W93-70408 465-42-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**APPLICATION OF REMOTE SENSING IMAGERY TO NEOTECTONIC PROBLEMS IN THE BAJA CALIFORNIA PENINSULA**

M. M. Miller 818-354-4977

The objectives of this RTOP are as follows: (1) to understand the modern and recent kinematic framework of tectonic evolution of the western North American plate margin, specifically at the latitude of Baja California; (2) to resolve questions concerning the transfer of slip from spreading ridge-transform systems in the southern Gulf of California to offshore fault systems in southern California; (3) to generate a data base that elucidates the evolution of the Gulf of California and related deformation over the last 5 million years; and (4) to provide constraints for NASA supported geodetic studies in Baja California by identification and study of active faults. The approaches to accomplish this RTOP are as follows: (1) purchase, process, and interpret LANDSAT Thematic Mapper images for the Baja California Peninsula; (2) pinpoint areas of neotectonic activity and supplement the TM data base with SPOT data; (3) carry out geologic mapping and related field studies in areas defined by 1 and 2; and (4) interpret results in the context of the regional tectonics of western North America.

**W93-70409 465-43-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MULTISPECTRAL ANALYSIS OF THE STRATIGRAPHIC/STRUCTURAL RECORD, SOUTHWEST MEXICO**

H. R. Lang 818-354-3440

The primary objectives are to: (1) refine the geological understanding of the formation and evolution of the southern margin of the North American plate in the Guerrero-Morelos basin region of Southwest Mexico; (2) evaluate the utility of remote sensing conducted at visible-thermal infrared wavelengths combined with topographic data for mapping strata, defining stratigraphic sequences and modeling facies, and delineating geologic structures and inferring tectonic regimes; (3) integrate lithostratigraphic and structural information from remotely sensed and topographic data with that obtained from conventional field geological and geophysical data using the IGIS workstation; and (4) use results to test existing models and develop new models of Mesozoic terrane accretion/plate interaction along the southern edge of the North American plate. The approach is to acquire, coregister, and analyze remote sensing data from satellite and aircraft systems and conventional geological and geophysical data to: (1) define stratigraphic and basement units, map facies and determine their physical, chronological, and mineralogical attributes in order to infer environments of deposition and paleogeography; and (2) map structure/measure kinematic indicators to infer tectonic evolution. A final product will be an east-west crustal traverse through the region of study representing a testable model for lithospheric formation and evolution of the southern edge of the North American plate and its interaction with the Pacific and Caribbean plates in the Southwest Mexico study area. Field and laboratory studies will be performed to support interpretations.

**W93-70410 465-44-00**

Langley Research Center, Hampton, VA.

**SATELLITE OBSERVATIONS OF VOLCANIC AEROSOLS**

M. P. McCormick 804-864-2669

This RTOP results from the proposal, 'Satellite and Lidar Measurements of Stratospheric Volcanic Aerosols and Applications to Climate Change', (NASA #1461-VCIP-014), a study which was selected for funding. The objective is to use lidars and the Stratospheric Aerosol Measurement (SAM) II/Stratospheric Aerosol and Gas Experiment (SAGE) (SAM II/SAGE) satellite experiments to provide global data pertinent to the role stratospheric aerosols of volcanic origin play in climate change. Langley's expanded long term lidar and satellite stratospheric aerosol data base along with

extensive aircraft and field mission validation data will be used to study the impact of volcanic eruptions on climate. Investigations of aerosol cloud height and spatial distribution, the global dispersion of aerosol, aerosol mass, size distribution, surface area and residence time resulting in global maps and time series plots will be produced and reported to the Volcano-Climate Interaction Program (VCIP) Team.

**W93-70411 465-44-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**REMOTE SENSING OF ACTIVE AND RECENTLY ACTIVE VOLCANIC FEATURES**

D. C. Pieri 818-354-6299

Under this RTOP we request support to continue acquisition and analyses of multispectral data on active and recently emplaced volcanic features and related aerosol, gas, and particulate emissions across a variety of wavelengths from UV through short and long wavelength thermal infrared, and radar (e.g., UVS, AVIRIS, NS001, TMS, TM, TMS, SPOT, Zeiss, SAR, and Inframetrics 525). We are investigating the relationship between remotely acquired data and the spectral-physical characteristics and processes of active and emplaced volcanics (e.g., composition, surface texture, formation parameters). We are continuing comprehensive analyses and comparisons between the Hawaiian (Mauna Loa-Kilauea), Italian (Etna), and Kamchatkan (Tolbachik) basaltic shields, including analyses of thermal data from active lava flows, statistical distributions of flow ages, multispectral mapping, and theoretical process models of surface and atmospheric components. We will continue spectra vs. process analyses of explosive volcanoes, such as Vesuvius and St. Helens, as well as volcanoes on the Kamchatka Peninsula (Ksudach, Bezmyanny) and Alaska (Katmai). In addition, we are beginning a unique 10-year retrospective time-series analyses of Landsat Thematic Mapper (TM) data of Etna, including comparisons between remotely perceived activity and geophysical data. Finally, we are continuing recent retrospective and prospective work on the impact of near-polar eruptions on short term weather/climate and ozone abundance at high latitudes. We are drawing on data and techniques already acquired and proven by the JPL Geology Group and on ongoing work and accomplishments under this program in theoretical and applied volcanology. We are applying a variety of remote sensing techniques from satellites and aircraft to address basic volcanological problems (e.g., thermal budgets of active lava flows), and are extending insights toward global habitability and societal risk concerns. In addition, under this RTOP, support is requested for continuing participation, planning and execution of a cooperative volcanology and remote sensing program with the Russian Academy of Sciences. Funds are also requested here for the development of the proposed Orbiting Volcanological Observatory.

**W93-70412 465-44-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**EVOLUTION OF VOLCANIC TERRAINS**

M. J. Abrams 818-354-1799

The long range goals of this study are to: (1) develop weathering histories of lava flows along strong rainfall gradients to infer climatic influences; (2) study and date cinder cones and maars to determine effects of climate on volcanic landforms, and correlate with glacial chronology; (3) determine the thermal characteristics of active volcanic phenomena, such as lava tubes, domes, and lava lakes to assess thermal budgets and understand dynamics of lava emplacement; and (4) measure SO<sub>2</sub> emissions from Mt. Etna using thermal images and the LOWTRAN7 model to determine tropospheric contributions of this volcano to the SO<sub>2</sub> budget. Our approach is to combine modeling, processing and interpretation of aircraft and satellite image data, field measurements and mapping, and laboratory studies to address the objectives. In Hawaii, we will combine Digital Elevation Model (DEM) data with aircraft data to determine the effects of varying climate on single flows, using elevation controlled rainfall gradients to examine weathering effects. We will use TMS and NS-001 data to study the thermal dynamics of lava tube systems to estimate



heat losses of flow fields and better understand flow dynamics. In Mexico, we will use Thematic Mapper (TM) data and field work to map and date a field of cinder cones and maars to determine the interaction of lake and water table levels on landforms; we will correlate the volcanic chronology with glacial chronology to determine the paleoclimate of the Serdan Basin. For Mt. Etna, we will use the Thermal Infrared Imaging Spectrometer (TIMS) to measure SO<sub>2</sub> absorption, and combine this with LOWTRAN7 modeling to determine the volcano's SO<sub>2</sub> flux. This will be extended to Hawaii, and ground based COSPEC and spectrometer measurements will be acquired for validation. New work in Kamchatka will compare processes at Tolbachik and Uzon with their Hawaiian and Cascade counterparts.

**W93-70413****465-44-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**VALIDATION OF VOLCANIC PLUME MODELS WITH REMOTE SENSING**

S. M. Baloga 202-479-2609

The objective of this study is to validate theoretical models used to describe buoyant volcanic plumes. This will be accomplished by first critically examining the physics in contemporary plume models, secondly by analyzing them for quantities that must be measured, and finally by conducting these measurements using available ground based and airborne remote sensing instruments. We will determine under what atmospheric conditions and initial parameters the models can be used. In this way, we will improve the understanding of volcanic ash and gas injection into the upper atmosphere. An additional goal of this study is to demonstrate the usefulness of simultaneous visible, UV, and IR measurements of buoyant plumes and to develop measurement methodologies that can be used with instruments on large satellite platforms such as the Earth Observing System (EOS). The first phase of this study has resulted in an internally consistent model of buoyant plume dynamics based on the Morton system of equations for volume, momentum, density and temperature. The second phase has involved a thorough study of the effects of variations in several plume parameters. Consequently, several variables (temperature, density, condensation rate, particle fallout rate) have been identified that can critically effect calculations. The next phase of this study will involve ground based remote sensing measurements of some of these variables in order to determine the adequacy of the physical description. Finally, the regimes for which Morton type models are valid will be characterized according to initial vent conditions and standard fluid dynamics parameters such as the Reynolds and Richardson numbers.

**W93-70414****465-44-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MEASUREMENT OF VOLCANIC GASES**

J. A. Crisp 818-354-9036

Volcanic gas emissions can have an important impact on atmospheric chemistry and greenhouse warming. Efforts to monitor these gases and to assess their global climate impact by remote sensing are seriously hampered by the lack of a complete and accurate database of molecular line parameters for all volcanic sulfur species. The absorption line parameters required are the positions, intensities, transition lower state energies, and line shapes. We are compiling a supplemental database that includes the important volcanic gases not available in the 1991 Air Force Geophysics Laboratory High Resolution Transmission (HITRAN) or GEISA compilations. Existing published results will be converted to the HITRAN database format and new laboratory studies for important sulfur carrying species will be undertaken. The resulting supplemental database will be described in a technical report. With HITRAN and the new supplemental database as input for a radiative convective model, the greenhouse warming potential of a large volcanic eruption will be studied and accuracies and detection limits will be determined for measurements of volcanic gases by remote sensing instruments. High resolution laboratory spectra will be recorded in the 1.2 to 12 micron region using Fourier transform absorption spectrometers to provide reference

data. Previously published studies on absorption features for all of the important volcanic gases over the 1 to 12 micron wavelength range will be reviewed and validated using the new spectra, and new predictions will be done to form the supplemental molecular database of volcanic species. Portions of the laboratory spectra will be measured as needed for at least two of the four important sulfur species. In particular, detailed measurements and quantum mechanics analyses will be performed to derive line intensities and line shape parameters of prominent OCS and H<sub>2</sub>S bands. With the absorption line database as input for a radiative convective model, the greenhouse warming potential of a large volcanic eruption will be studied. Radiative transfer calculations will be used to determine detection limits and accuracies for measurements of each of the volcanic gases by instruments on Earth Observing System (EOS) and Upper Atmosphere Research Satellite (UARS) platforms.

**W93-70415****465-44-06**

Ames Research Center, Moffett Field, CA.

**VOLCANIC CLOUD DISPERSION, CHEMISTRY AND MICROPHYSICS: AN ANALYSIS OF THE EL CHICHON ERUPTION**

R. E. Young 415-604-5521

The objective of this RTOP is to simulate the dispersion and climate effects in the stratosphere of the El Chichon and Mt. Pinatubo volcanic aerosol clouds. An extensive data set obtained from ground based, aircraft, and satellite measurements exists for the years immediately following each eruption. The results from the model simulations will be compared to the data, with the intent of developing a better understanding of stratospheric transport processes and climatic effects of large aerosol loadings in the stratosphere. The approach is to use a three-dimensional stratospheric circulation model coupled to a three-dimensional aerosol/transport model to simulate the volcanic aerosol clouds. The circulation model calculates stratospheric wind and temperature fields, which are then input to the aerosol model to conduct the transport and compute aerosol microphysical processes such as coagulation and sedimentation. The coupled models have the capability to investigate chemical, microphysical, and global transport processes in the stratosphere important for simulating the behavior of large aerosol injections into the stratosphere.

**W93-70416****465-45-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**CARBON MASS BALANCE DURING SOIL EVOLUTION ALONG CLIMATE GRADIENTS**

O. A. Chadwick 818-354-6229

The objective of this research is to develop datasets that will allow prediction of the response of soil processes and their resulting properties to climate change. Most soil processes leave their imprint on the geologic substrate over relatively long periods of time that do not allow in situ measurements of the actual processes. The practical approach to understanding the role of climate change on pedologic processes is to develop time-climate matrices following the chrono-climosequence concepts to quantify soil properties and infer the time/climate processes that underlie the changes in properties. The approach is to focus on elemental and mineralogical gains and losses which will emphasize the essential connections among the pedological, hydrochemical, geological, and atmospheric environments. Chemical elements such as carbon, nitrogen, phosphorus, calcium, silicon, and aluminum will be used as tracers in a mass balance analysis that provides functional relationships among soil chemical composition, bulk density, and volume change in relation to parent material. These analytical functions are based on the principle of conservation of mass and include terms that quantify the cumulative deformation during soil development and the mass flux into/out of the soil and between horizons. In addition to documenting deformation and mass flux during pedogenesis at different times during the evolution of soils developing under different climates, we will quantify the elemental distribution among: (1) mineral, noncrystalline inorganic, and organic phases, and (2) particle-size



separates. The purpose of this effort will be to document the rates at which primary minerals are weathered and the types of secondary mineral synthesis that occur under different climate regimes. The primary geographic/geomorphic areas covered by this research will be (1) marine terraces along the Pacific coast of Oregon, California, Mexico and New Zealand, (2) lava flows on the Island of Hawaii, (3) glacial deposits and fluvial terraces in the Basin and Range and Rocky Mountains, and (4) Queensland, NE Australia. Each of these sites provides important climate gradients, parent material uniformity, and geographic diversity. The level of emphasis for each area will be determined during preliminary field investigations.

**W93-70417****465-65-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AVIRIS OPERATIONS**R. O. Green 818-354-9136  
(463-75-63; 665-81-08)

The objective is to support the activities required to acquire, calibrate and distribute data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) for NASA sponsored science investigators in FY-93. AVIRIS measures the total upwelling radiance incident at the sensor in 224 channels with nominally 10 nm spectral sampling and 10 nm spectral response functions (FWHM) from 400 to 2500 nm in the electromagnetic spectrum. Data from these channels are acquired at nominally 20 by 20 m spatial resolution with an 11 km by up to 100 km image extent. All distributed AVIRIS data are calibrated with respect to spectral, radiometric and geometric characteristics. A brief summary of the AVIRIS operations assumptions for FY-93 are as follows. (1) Routine and preventative maintenance will be undertaken so that no degradation in performance occurs. (2) For six contiguous months, AVIRIS will be at JPL for preventative maintenance and refurbishment following the 1992 flight season. (3) The following data acquisition deployments away from JPL will be supported: (a) 14 weeks at Moffett Field, CA, and (b) two three-week deployments to Wallops Island, VA. (4) Up to 1000 calibrated AVIRIS scenes will be distributed to sponsored investigators. (5) Cost estimates for transportation of AVIRIS and travel to support launch site operations are based upon FY-92 travel and shipping costs. The objectives will be fulfilled through the following activities at JPL: (1) AVIRIS task and RTOP management; (2) calibration and validation science; (3) experiment coordination and mission planning; (4) data decommutation, calibration and distribution; and (5) sensor operations, calibration and maintenance. These activities are described fully in 'Justification, Objectives and Plans, Review and Reporting'.

**W93-70418****465-66-00**

Ames Research Center, Moffett Field, CA.

**AIRBORNE SCIENCE MANAGEMENT OPERATING WORKING GROUP SUPPORT**J. G. Lawless 415-604-5900  
(462-79-00; 469-99-00)

The objective of this work is to provide general support to NASA's Airborne Science Management Operation Working Group. Support will be provided for planning activities related to Surface Remote Sensing Program usage of NASA's science applications aircraft. Staff support is also necessary for regular meetings of the Aircraft Science Management Operations Working Group.

**W93-70419****465-67-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AIRBORNE INTERFEROMETRIC TOPOGRAPHY**H. A. Zebker 818-354-8780  
(462-74-01)

The objective of this study is to develop an instrument capable of mapping the topography of the Earth's surface at high spatial and vertical resolution, using the technique of radar interferometry to produce a data set which is useful in a variety of Earth science investigations. Our specific objective here is to develop such an instrument on an aircraft system in order to prove the technology in an operational environment, begin to acquire and distribute a

data set over a variety of terrain types which will be available to the science community, and develop algorithms and procedures applicable to future spaceborne missions such as TOPSAT. Our approach, consisting of an instrument we call TOPSAR, is to implement a cross track interferometer mode on the existing NASA DC-8 radar for precision topographic mapping. This approach is of minimum cost as it utilizes the existing C-band multichannel radar hardware as much as possible. The major changes required to the existing system are procurement of two new radar antennas, fairings for mounting them on the DC-8, and changes to the radar RF switching network. Eventually, a new radar processor which produces low phase noise images will be needed. Our goal is to produce less than 2 m height accuracy DEM's with precisely co-registered L and P band polarimeter radar images. This capability follows from operating the L and P band systems simultaneously with the interferometer, and processing the raw data in an integrated manner. This will result in geometrically rectified and cartographically accurate polarimeter data. The three year approach is to (1) develop a new set of interferometric radar antennas, integrate them with the DC-8, and verify the installation with test flights in the U.S. and Italy; (2) develop a phase-accurate processor with aircraft motion compensation algorithms, and produce a sample 2 m map; and (3) integrate the system with the DC-8 P and L band radars in a manner that will allow it to be operated in a routine manner, should NASA wish to fund it as part of the AIRSAR system. In addition, we will, during the course of this study, acquire data over a variety of sites of differing Earth science applications to support the science community at large and familiarize them with the generation and use of digital topographic data.

**W93-70420****465-68-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATIONS**J. J. vanZyl 818-354-1365  
(462-75-62; 665-81-08)

The purpose of this plan is to provide the NASA remote sensing program with an Airborne Synthetic Aperture Radar (AIRSAR) system for purposes of testing and evaluating radar techniques in parameterizing surface physical characteristics. In addition, this work serves to develop engineering methods that can be and are used to fabricate spacecraft SAR systems. AIRSAR is a three-frequency (P-, L- and C-band), fully polarimetric SAR that acquires all twelve data channels simultaneously, resulting in co-registered images at all frequencies. In FY-93, the AIRSAR will be maintained and operated during flight missions as prescribed by NASA. The data will be converted to imagery and disseminated to the users in accordance with procedures established by NASA and JPL. Flight hours for engineering testing will be used to assure the proper performance of the SAR and to test new concepts planned for future spacecraft SAR's. The plan is to reduce the data from up to 600 scenes to three frequency imagery, each with four polarizations (12 images). System evaluation will be carried out to assess the validity of the data. We shall calibrate the AIRSAR data using the results from calibration flights over Rosamond Dry Lake in California. The development of an upgraded ground data processing facility will be completed in FY-92 under separate funding; the new system will allow improvements to be made in data quality and increase the processing throughput.

## Climate and Hydrologic Systems Modeling and Data Analysis

**W93-70421****578-10-00**

Marshall Space Flight Center, Huntsville, AL.

**MODELING AND DATA ANALYSIS, PHYSICAL CLIMATE AND HYDROLOGICAL SYSTEMS, DATA ANALYSIS**

R. J. Koczor 205-544-3078

The objective is to contribute to the NASA Global Scale Processes Research Program objectives by performing diagnostic and theoretical studies of global-scale atmospheric systems to: (1) develop new and improved spaceborne atmospheric sensing techniques; (2) develop new techniques to extract information from and more fully utilize existing and planned spaceborne atmospheric sensing systems; and (3) contribute to the development of our understanding of global scale atmospheric processes. The approaches are to conduct detailed analyses with space and ground-based data sets, guided by theoretical studies, to understand the role of latent heat release in the dynamics of cyclones; examine global atmospheric processes to gain improved understanding of the scales of motion; develop techniques for including satellite data in diagnostic procedures; and develop strategies and mission concepts to measure global scale processes from space platforms.

**W93-70422****578-11-01**

Ames Research Center, Moffett Field, CA.

**CLIMATE MODELING WITH EMPHASIS ON AEROSOLS AND CLOUDS**J. B. Pollack 415-604-5530  
(460-43-47; 460-42-10)

The objectives of this RTOP are the following: a coordinated set of theoretical, laboratory, and field investigations of the chemical and radiative properties of clouds and natural (e.g., volcanic) and man-made atmospheric aerosol particles is conducted in order to assess their impact on regional and global climate. The field investigations are intended to provide complementary information on clouds and aerosols to that being obtained from spacecraft platforms (e.g., SAM, SAGE II and SME) so as to insure that a comprehensive set of properties is gathered for climatic analyses. The theoretical and laboratory tasks are directed at interpreting and utilizing the data sets to perform the desired climatic assessments. The approaches of the RTOP are as follows: the centerpiece of the field investigations is a set of coordinated experiments which are flown together on appropriate aircraft platforms. Both theoretical modeling and laboratory studies are used to define the mechanisms of aerosol and cloud formation to provide hypotheses that can be tested by the field investigations and to ultimately provide predictive tools. Theoretical investigations involving radiative transfer, dynamics, and particle formation are utilized for making the climatic assessments, including simulations with a three-dimensional climate model.

**W93-70423****578-11-02**

Goddard Inst. for Space Studies, New York, NY.

**EXTENSION AND TESTING OF THE HYDROLOGIC PARAMETERIZATION IN THE GISS ATMOSPHERE GCM**

Peter Eagleson 212-678-5588

The overall objective of this work is to test and improve the capability of the Goddard Institute for Space Science (GISS) general circulation model to reproduce critical aspects of global hydroclimatology, via the development of new diagnostic methods for evaluating the cycling of moisture in the model and the implementation of subgrid-scale fluctuations in the model's ground hydrology parameterization. The approaches are (1) development of a global one-dimensional analog of the GISS GCM that captures the essential radiative and convective processes of a global climate; (2) comparison of various aspects of proposed GCM ground hydrology improvements in the one-dimensional model; and (3) implementation of a new ground hydrology model in the GCM based on the results of the 1-D screening tests.

**W93-70424****578-12-01**

Goddard Inst. for Space Studies, New York, NY.

**EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES**

William B. Rossow 212-678-5567

The objectives are to (1) develop new multi-channel, multi-instrument cloud analysis methods, including new cloud detection schemes and more sophisticated radiative transfer models; and (2) develop analysis methods to infer cloud-radiative feedbacks from the International Satellite Cloud Climatology Project (ISCCP) data. The approaches are to compare ISCCP results to observations from a full complement of instruments on the NOAA polar orbiters, including sounders, and to measurements by other instruments, such as microwave radiometers; develop methodologies to infer cloud-radiative feedbacks from ISCCP data; and compare results to products produced by ERBE, the Surface Radiation Budget Project, and climate model simulations.

**W93-70425****578-12-02**

Goddard Inst. for Space Studies, New York, NY.

**AN INTEGRATED STUDY OF SURFACE PROPERTY VARIATIONS**

William B. Rossow 212-678-5567

The objective of this RTOP is to develop a combined analysis procedure, using both satellite and surface observations, to obtain accurate estimates of global surface albedo and temperatures. The approach is to: (1) combine the International Satellite Cloud Climatology Project (ISCCP) results with other measurements of the surface at other wavelengths and from conventional surface measurements to determine a more accurate representation of these key surface variables over the whole globe for two years, one 'normal' year and a 'perturbed' year (e.g., El Nino); and (2) extend ISCCP calibrations to other spectral bands.

**W93-70426****578-12-19**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**REMOTE SENSING OF AIR-SEA FLUXES**

W. T. Liu 818-354-2394

(578-12-18)

The objectives are to study, using spaceborne sensors, the interactive processes of ocean-atmosphere exchanges in momentum, heat, and moisture and their effects on ocean thermodynamics and dynamics. Feasibility studies on computing latent heat flux using Seasat/Scanning Multichannel Microwave Radiometer (SMMR) data were successfully performed. A global relation between precipitable water and surface humidity was derived. Adaptation of bulk parameterization models to satellite data in the tropical oceans was examined. Four years of Nimbus/SMMR data were evaluated and the latent heat fluxes computed in the tropical Pacific; the seasonal cycles and the anomalies during the 1982 to 1983 El Nino Southern Oscillation (ENSO) episode were studied. Combining with surface insolation, the net heat flux fields were constructed as part of the Tropical Ocean Global Atmosphere (TOGA) Heat Exchange Project. The results were used to study thermal forcing of the sea surface temperature changes in the eastern tropical Pacific. In light of our results, the conventional approximations used in computing latent heat flux in ocean numerical models were evaluated. High frequency variability of humidity distribution in the atmosphere was studied to understand the physical basis and limitation of our technique for estimating surface level humidity and humidity profiles from satellite data. Wind forcing of deep current during the OCEAN STORM experiment was studied. Extension of our heat flux technique to use Special Sensor Microwave Imager (SSM/I), Advanced Very High Resolution Radiometer (AVHRR) and International Satellite Cloud Climatology Project (ISCCP) data on global tropical ocean is being pursued. Evaporation as an ocean thermostat and precipitable water as a greenhouse gas will be studied. A state-of-the-art eddy resolving ocean general circulation model is being implemented to study the ocean's responses to surface forcings.

**W93-70427****578-12-20**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**METEOROLOGICAL PARAMETERS EXTRACTION**

M. T. Chahine 818-354-6057

(578-12-21)

The overall objective of the proposed research is the

development of accurate numerical analysis methods to retrieve, from satellite data, important meteorological parameters needed for weather and climate studies. To accomplish this we plan to conduct theoretical and applied studies for the continued improvement of numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the NOAA High Resolution Infrared Sounder/Microwave Sounding Unit (HIRS/MSU) sounders; apply the retrieval methods to produce a ten year data set (1979 to 1989) from the HIRS/MSU of several meteorological parameters such as clear-column vertical temperature and humidity profiles, sea-surface temperature, and the distribution of cloud heights and amounts; verify the accuracy of the results by participation in national and international workshops dedicated to this objective, and by comparison with co-located radiosonde and sea-surface data and with cloud nephelanalysis obtained independently from other sources; and apply the results to observe and study various air-surface interaction processes on monthly to seasonal timescales. Simultaneous determination of the atmospheric and surface thermal structure and the cloud distribution provides information on heat sources and sinks, storage rates and transport phenomena in the atmosphere. Such information is critical in determining the driving mechanisms for motions in the atmosphere and oceans and in improving numerical weather prediction.

**W93-70428****578-12-21**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ATMOSPHERIC PARAMETER MAPPING**

K. J. Hussey 818-354-4016

(578-12-20)

The primary objective of the Atmospheric Parameter Mapping (APM) task for FY-93 is to initiate a multi-year archiving and visualization task, beginning with the development and delivery of a prototype compact disc (CD) browse product designed to greatly facilitate the analysis, acquisition, visualization, and exchange of satellite imagery from such platforms as NOAA High Resolution Infrared Sounder 2/Microwave Sounding Unit (HIRS2/MSU) and Atmospheric Infrared Sounder (AIRS). The secondary, related objective for FY-93 is to develop tools and methodologies which serve to streamline and accelerate the process of utilizing and preparing satellite data, such as those found on the proposed CD browse product, for high-quality visualizations such as parameter maps and time-series imagery. In conjunction with atmospheric scientists at JPL, the proposed approach to completing the primary objective of the APM task will be as follows. The browse product will incorporate a user-friendly Macintosh-based application interface designed to allow the user to visually inspect the data files stored on a browse product CD. All files will be in the Hierarchical Data Format (HDF) developed by the National Center for Supercomputing Applications (NCSA). Data descriptors such as file name, parameter type, and data resolution will be stored in every file. Each browse product CD will contain HDF-based satellite data, the Macintosh interface application, and non-proprietary NCSA analysis and display applications designed for HDF data usage. Through the use of the proposed application interface, an atmospheric scientist will be able to examine the contents of a browse product CD, obtain descriptive information about any HDF file, use data filters to transform or convert HDF data to a different format type, and launch NCSA applications. The approach to completing the secondary objective will be built upon existing image processing techniques currently utilized in the production of high-quality visualizations. The current procedures undertaken to prepare raw atmospheric satellite data for high-end visualizations will be reviewed, revised, and expanded upon where necessary in order to provide a solid bridge between raw, archived data, and high-quality visualizations suitable for formal presentations and publications. Once acceptable methodologies have been established, improved techniques for processing the archived data will be constructed and incorporated into user-friendly, easily expandable modular procedures designed for use by atmospheric scientists.

**W93-70429****578-12-59**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**OUTGOING SPECTRAL RADIANCE: A CLIMATE DIAGNOSTIC**

R. D. Haskins 818-354-6893

The objective of this RTOP is an evaluation of the use of spectral radiances as diagnostics of physical climate processes; a concurrent investigation will be made of errors in forward calculations of radiances. This collaborative effort between Atmospheric and Environmental Sciences, Inc. and the Jet Propulsion Laboratory is addressing the following research tasks: (1) the response of the earth's outgoing spectral radiance to changes in physical processes as revealed in simple climate models; (2) the development of a methodology for utilizing satellite radiance measurements for the present purposes by studying the Infrared Interferometer Spectrometer (IRIS)-D data from the NIMBUS 4 Satellite; (3) the validation of our ability to model high resolution spectral radiance data (approximately 1/cm) using High Resolution Interferometer Sounder (HIS) spectral radiance observations; and (4) the implementation of indicated improvements in the forward radiative transfer model. The results developed here will be evaluated in the context of application to Earth Observing System (EOS), particularly with respect to the Atmospheric Infrared Sounder (AIRS) Experiment.

**W93-70430****578-21-12**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**TROPICAL OCEAN CIRCULATION FROM ALTIMETRY AND NUMERICAL MODELING**

C. M. Perigaud 818-354-8203

The long-term objective of this RTOP is to use satellite altimetry for describing, understanding (and predicting) oceanic circulation and its variations in the tropics. The goal is to make the best possible use of TOPEX/POSEIDON altimetry data. This is being investigated by: (1) altimetric data processing and analysis (until TOPEX/POSEIDON data are available, Geosat altimeter data are used); (2) estimation of data errors due to orbit, tropospheric, and tidal error; (3) simulation of oceanic circulation using different numerical approaches (reduced-gravity model, Ocean General Circulation Model); (4) analysis of model sensitivity to wind error; (5) comparison of observed and simulated sea level variations; and (6) assimilation of altimetric data into numerical model of ocean circulation. Methods for fitting ocean models to altimeter data are investigated in three directions: (1) suboptimal estimation using updating (or nudging); (2) optimal estimation using Kalman filtering; and (3) optimal estimation using adjoint approach. The present RTOP is for the third year of the proposal. Objectives 1 and 2 are achieved with Geosat over the Indian Ocean, over the tropical Pacific, and for data error analysis. Objectives 3 and 4 are achieved with shallow-water model over the Indian Ocean (in collaboration with Dr. Delecluse), and Oceanic General Circulation Model (OGCM) (in collaboration with Dr. Chao) over the Pacific Ocean, models forced either with Florida State University (FSU) or European Center for Medium Weather Forecasts (ECMWF) winds. The next step is to run OGCM over the Indian Ocean (in collaboration with Dr. Delecluse). Objective 5 is well advanced: one publication, one submitted and two in preparation over the Indian Ocean, and two submitted over the Pacific. Objective 6-1 is being applied for El Nino predictions. Objective 6-2 was achieved for linear equatorial waves; it is being applied on other similar cases. Objective 6-2 was developed and is being applied to a shallow-water model.

**W93-70431****578-22-24**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**OCEAN CIRCULATION FROM SATELLITE ALTIMETRY**

L.-L. Fu 818-354-8167

The long-term objectives of this study are: (1) to investigate the utility of satellite altimetry as a tool for studying the circulation of the global oceans; and (2) to explore ways to combine altimetry observations with ocean models to achieve an optimal description of ocean circulation and its variabilities. The data sets for the study include those from Geosat, ERS-1, and TOPEX/POSEIDON. We are in the process of establishing an end-to-end data processing

facility with the capability of data browsing, editing, gridding, orbit correction, tidal correction, mapping, and animation. Optimal estimation methods have been developed for correcting the orbit errors and the tidal errors, and also for space-time gridding and mapping. We have developed efficient schemes for applying Kalman filtering and smoothing techniques to assimilating altimetry data into ocean circulation models. Using these tools, we will conduct both descriptive and modeling studies. The following are the four near-term objectives. The first is basin-scale variability. We have generated a series of global sea level maps at a 5 x 5 degree grid and three-day interval using the Geosat Exact Repeat Mission (ERM) data. This work will be extended to the first 18 months of Geosat crossover data sets. The resulting four-year global data set will be used for studying the basin-scale variability and its relation to atmospheric forcings. The second is ERS-1 altimetry. Due to the non-repeating orbit of ERS-1, crossover analysis techniques will be applied to removing the orbit errors and constructing sea level time series for basin-scale variability studies. The third is modeling/data assimilation. Kalman filtering/smoothing techniques will be applied to assimilating the Geosat data into models of the Atlantic and the Pacific basins and eventually into a global coarse-resolution model (in collaboration with Dr. I. Fukumori). The fourth is TOPEX/POSEIDON data processing and evaluation. An operational procedure will be established to produce sea level maps from TOPEX/POSEIDON data. This activity will be funded largely by the TOPEX/POSEIDON Project. The sea-state bias will be evaluated using waveform analysis (in collaboration with E. Rodriguez).

**W93-70432****578-22-25**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**STUDIES OF SEA SURFACE TEMPERATURE AND TOPOGRAPHY**V. Zlotnicki 818-354-5519  
(578-22-27)

The goal of this work is to measure, understand, and help predict the circulation of the oceans at mesoscales and longer. Satellite altimetry, infrared, and microwave data combined with in-situ data, and data assimilation into a hierarchy of numerical models are the areas of emphasis. The current emphasis is on the three altimetric missions, Geosat, ERS-1, and TOPEX/POSEIDON. The main objectives for the coming year are: (1) to assess TOPEX/POSEIDON data, and tie it to the tide gauge network; (2) to assess and optimize orbit and environmental corrections to ERS-1 data by minimizing their discrepancy from tide gauge data; and (3) to combine TOPEX and ERS-1 altimeter crossover data with our existing Geosat Exact Repeat Mission (ERM) database, and ascertain whether interannual ocean changes can be distinguished from differences in the measuring systems. We will use: (1) a colinear difference adjustment, fitting a quadratically varying once/rev within an orbit arc, with tide constraint equations; (2) a similar approach to (1) for ERS-1 internal adjustment; and (3) a crossover adjustment between ERS and TOPEX data, fitting the time-averaged component of the altimeter's observations. The principal investigator will devote 70 percent of the time to these tasks. An additional 10 percent of the time, funded under this RTOP, is used to manage all the activities of the Ocean Groups Computer System (RTOP 578-22-27). The remaining time will be devoted to the TOPEX project and Earth Observing System (EOS) interdisciplinary work. Funds are also requested for a half time programmer, to purchase meteorological data from the European Centre for Medium Range Weather Forecast, and to purchase selected in situ data from the National Ocean Data Center.

**W93-70433****578-22-26**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**LARGE SCALE AIR-SEA INTERACTIONS**D. Halpern 818-354-5327  
(578-22-29)

Understanding the role of wind-driven ocean circulation in the dynamics of large-scale, seasonal-to-interannual variations of sea surface temperature (SST) and biogeochemical constituents,

both in tropical and middle latitudes, is a basic tenet of the World Climate Research Program (WCRP) Climate Variability (CLIVAR) Program and of the Intergovernmental Panel on Climate Change (IPCC). Research on large-scale, long-period ocean-atmosphere interactions involves analyses of satellite observations and model simulations. Topics include the annual and interannual variations of the Pacific North Equatorial Countercurrent (NECC) and the space-time structure of the global surface wind field. During an El Nino, the geostrophic component of the NECC transport increases which suggests the NECC may be an important contributor toward the generation and maintenance of El Nino. In flowing eastward against the prevailing westward winds, the NECC represents an ocean circulation phenomenon whose dynamics have long interested oceanographers. The degree of Sverdrup balance throughout an annual cycle is not known because of the heretofore absence of suitable measurements. Geodetic Satellite (GEOSAT) estimates of the surface geostrophic current and simulations of the monthly transport of the Pacific NECC with an ocean general circulation model exhibited large variations in longitude. The surface geostrophic current was computed from GEOSAT data and will be continued with Earth Resource Satellite-1 (ERS-1) and Topographic Ocean Experiment (TOPEX)/POSEIDON altimeter data. The Remote Sensing Systems Special Sensor Microwave Imager (SSM/I) surface wind speed field will be used to detect interannual variations and to evaluate improvements of the European Center for Medium Weather Forecasts (ECMWF) wind data product.

**W93-70434****578-22-27**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**JPL OCEANOGRAPHY GROUP COMMON COMPUTER SYSTEM**V. Zlotnicki 818-354-5519  
(578-22-25)

The goals of this task remain as in previous years: to provide a multi-user computer system serving the basic computing and data management needs of the Physical Oceanography and Biological-Polar Oceanography groups at JPL, both now and in their evolving roles in interdisciplinary studies. The computers funded under this RTOP are used to organize, process and analyze large volumes of satellite data and numerical model output. This RTOP assumes that a supercomputer, such as exists at Goddard, JPL, or Ames, are available to run numerical ocean models at no cost to either this RTOP or those of the investigators of the Oceanography groups, as has occurred for the past years. The computer system is based on a closely networked group of UNIX machines, mostly SUN's, one Silicon Graphics, one Hewlett Packard, microVaxes and Macintoshes, and shared peripherals accessible to all members of the group. Some of the machines on the network are shared among all group members on an equal footing; other machines are task-specific, in that they were purchased outside this RTOP, but they are shared in a not-to-interfere basis with other group members. Upgrades to this Oceanography Computing Network (OCN) are dictated by the ever-increasing size of the data handled, and the increased sophistication of the analysis, modelling, and assimilation tasks performed. The open architecture, and standards such as UNIX and the SCSI interface, allows many economical upgrade paths. Between FY-88 and FY-90 this RTOP included all hardware and software requests for both groups. Starting in FY-92, our request includes only those needs common to many members, such as system managers, software maintenance, upgrades to large shared machines (the Silicon Graphics and Hewlett Packard), networking needs, etc. Hardware and software unique to a particular task are now requested and justified together with that task. The request for this FY includes system managers (1.5 wy), maintenance contracts for hardware and software, supplies (b/w and color ribbons and paper, magnetic tapes), increased disk space to provide convenient access to large on-line datasets, CD-ROM writer, an additional copy of IDL, and a second HP work station.

**W93-70435****578-22-29**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GLOBAL MONTHLY MEAN OCEAN VARIABILITY**

D. Halpern 818-354-5327

(578-22-26)

The unique perspective from space encourages observation of the global ocean, which is an essential component of the climatic system. Now, in the early stages of creating a long time series, it is appropriate to develop methods for presenting global multi-variable distributions. Halpern et al. (1992) published an atlas of monthly mean distributions of satellite measurements of surface wind speed, sea surface temperature, and sea surface height variation from Jan. to Dec. 1987. This was the second volume of the series. The first volume (Halpern et al., 1991) described 1988. The third volume, which covers 1989, will also be published in FY-92. The following monthly mean global distributions for 1987 and 1988 were presented with a common color scale and geographical map: sea surface height variation estimated from Geodetic Satellite (GEOSAT); surface wind speed estimated from the Special Sensor Microwave Imager (SSM/I) on a Defense Meteorological Satellite Program (DMSP) spacecraft; sea surface temperature estimated from the Advanced Very High Resolution Radiometer (AVHRR/2) on National Oceanic and Atmospheric Administration (NOAA) spacecraft; and the Cartesian components of the 10-m height wind vector computed by European Center for Medium Weather Forecasts (ECMWF). Charts of monthly mean value, sampling distribution, and standard deviation value were displayed. The atlas also contained annual mean distributions. Near-surface current components computed from satellite-tracked drifting buoy positions will appear for the first time in the 1989 atlas, which will not contain GEOSAT sea surface height variations. An atlas of monthly mean distributions of oceanographic variables is a living document: no two months are identical. Additional atlases are required for interpretations of global climate variations and to provide internally consistent data sets for climate initialization and validation studies. This RTOP describes publication of annual atlases for 1990 and 1991, each of which will use data processing procedures similar to that employed in the previous atlases.

**W93-70436****578-31-14**

Goddard Inst. for Space Studies, New York, NY.

**CLIMATE STABILITY: THE ROLE OF THE HYDROLOGICAL CYCLE AND THE THERMOHALINE CIRCULATION**

David Rind 212-678-5593

The objective of this RTOP is to investigate the likelihood of changes in North American Deep Water circulation by combining General Circulation Model (GCM) output with a simple ocean model.

**W93-70437****578-32-24**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ACTIVE/PASSIVE SEA ICE ANALYSIS**

F. D. Carsey 818-354-8163

Continued research and development will be conducted in the generation of sea ice geophysical quantities from satellite data. The objective of this work is the accurate estimation of heat, brine, and momentum fluxes from sea ice. The basic approach is the evolution and application of the Alaska Synthetic Aperture Radar (SAR) Facility Geophysical Processor System (ASF-GPS), which recently began routine operation, and its utilization in air-sea-ice interaction studies. In 1993 we plan to do the following: (1) utilize the ASF-GPS with properly processed Special Sensor Microwave/Imager (SSM/I) data in studies of the ice flux through Fram Strait and to estimate surface heat and brine fluxes of the Greenland Sea as part of the Greenland Sea Project; (2) examine the requirements of input data, algorithms, and data systems for the evolution of the ASF-GPS through the remainder of the decade including the flight phase of RADARSAT and Earth Observing System (EOS); (3) continue to serve as CI for the North-American Principal Investigators (PI's) to Earth Resources Satellite-1 (ERS-1); and (4) participate in the planning for a global sea ice data set with RADARSAT. In the Greenland Sea our approach is to use SAR data to track the ice and estimate convergence while using

SSM/I data and weather analyses to estimate thickness changes with time. A key element of the flux analysis is the conversion of SSM/I brightness temperatures (Tb's) to ice thickness changes; we have modeled the expected changes in Tb, and next we will devise methods to invert this method to generate ice growth from Tb observations. This procedure is known to be non-unique; thus, techniques must be developed to narrow the ice types as much as possible. Also, the impact of errors in the ice motion field must be examined as the opening and closing determined by the motion data used to correct Tb changes for the deformation. In the short term we will integrate ice motion data from AVHRR data determined by the Danish scientists in the Greenland Sea Project with ERS-1 SAR-derived data. The ERS-1 data have not yet been supplied, and there may remain bureaucratic obstacles to getting it. The community-written monograph, Microwave Remote Sensing of Sea Ice, should be on people's shelves by the start of FY-93.

**W93-70438****578-35-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SEA ICE MOTION IN THE PACIFIC SECTOR OF THE ARCTIC**

R. Kwok 818-354-5614

The goal of the proposed research is to characterize sea ice motion by combining observations from ERS-1 Synthetic Aperture Radar (SAR), Advanced Very High Resolution Radiometer (AVHRR), drifting buoys, ice station observations and meteorological fields (wind, pressure). Specifically, the proposed work will focus on the seasonal and regional behavior of ice motion in the Pacific Sector of the Arctic Basin covered by the Alaska SAR Facility (ASF) mask. This sector includes parts of the central Arctic, Beaufort, Chukchi and E. Siberian Seas. Sea ice motion will be partitioned into a large scale term and a small scale perturbation term based on the above observations. The large scale analysis provides a context in which to interpret the small scale behavior. In global system science, the large scale description is relevant to ice transport processes whereas the small scale description is important for characterization of local deformation and regional flux calculations. The spatial and temporal statistics of these motion terms will be analyzed. Interactions between the large scale and small scale motions will be quantified. Opening/closing calculations based entirely on kinematics will be compared with direct observations. Since E-ERS1 is one of the first missions to generate routine ice observations, it is also the intention of the studies to characterize the sensitivity of the geophysical measurements to errors in the observations from Synthetic Aperture Radar. The approach of the proposed work is to characterize sea ice motion using motion fields derived from ERS-1 Synthetic Aperture Radar (SAR) data, AVHRR data and drifting buoy data. We propose to combine these observations with ice station and meteorological observations to study the motion field in the Arctic at different length scales, from kilometers to thousands of kilometers. Specifically, we propose to study the regional and seasonal behavior of the ice motion in the Pacific Sector of the Arctic Basin. We will use the geophysical products as well as image products from the ASF. Although the operational limitations of ERS-1 will not provide the coverage for a synoptic view of the Arctic and peripheral seas, the SAR observations will nevertheless be able to answer some of the questions which have hitherto been unanswered due to lack of observational data.

**W93-70439****578-35-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MAPPING OF THE GREENLAND ICE SHEET: A CONTRIBUTION TO THE MONITORING OF GLOBAL CLIMATE**

R. Kwok 818-354-5614

It is proposed to use Synthetic Aperture Radar (SAR) data from the ERS-1 satellite to map the different physical and hydrologic boundaries of the Greenland ice sheet. The digital data set produced will consist of the geographic positions of the ice sheet margin and the boundaries between the various hydrologic zones on the ice sheet, as well as a 100-meter resolution mosaic of the ice sheet. The ice margin data will be compared with previous positions digitized from the published maps to identify sites of

major change. The data set of zonal boundaries will form a basis for monitoring their positions by subsequent mapping by the ERS-1 and other spaceborne SAR's. Finally, temporal monitoring on a monthly basis at four selected sites will be undertaken to investigate the nature and quantitative effect of seasonal changes on the backscatter signal. The approach is to develop techniques for mapping and change detection of SAR imagery. The primary tasks include (1) implementation of geocoding, terrain correction and mosaicking software to efficiently handle image data distributed by ESA; (2) compilation of the digital terrain data of the ice sheet; and (3) development of image analysis techniques for location of the zone boundaries in the SAR imagery.

**W93-70440****578-35-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MONITORING THE SEASONAL CYCLE OF SEA ICE IN THE ARCTIC BASIN FOR CLIMATE CHANGE WITH ERS-1 SAR**

B. M. Holt 818-354-5473

The principal task is to identify and monitor key seasonal transitions in the ice conditions in the Arctic Ocean that are discernible in ERS-1 C-band and JERS-1 L-band Synthetic Aperture Radar (SAR) imagery. The near-term objective is to determine the capability of these SAR's to monitor seasonal changes in sea ice and to assess the capability of the Alaska SAR Facility (ASF) ice classification algorithm for providing ice type and ice condition information by region and season. The approach will be to examine ERS-1 and JERS-1 SAR imagery of the Arctic Ocean acquired within the ASF station mask for seasonal variations as revealed in the backscatter signatures of the major ice types. The data will be analyzed by region and season. After calibration, the SAR signatures will be compared with scatterometer-derived signatures that are being utilized as look-up tables in the classification algorithm. The capability of the algorithm to assess these seasonal changes will be determined. The SAR data will be compared with other sensor data including Special Sensor Microwave Imager (SSM/I), Advanced Very High Resolution Radiometer (AVHRR) and LANDSAT imagery for clarification of features and ice type and environmental conditions. Any available measured ice parameters obtained coincident in time and location to ERS-1 and JERS-1 will be sought and used to verify ice type and condition. The signatures will also be compared to results of radar modeling efforts generated principally by co-investigator M. Drinkwater/JPL using ice and snow surface measurements. The thinner ice types have radar returns near the radiometric noise floor of the ERS-1 and JERS-1 SAR's and will be difficult to separate. The determination of thin ice will be examined by using zones of deformation derived from the ice motion analysis as indicators of areas of potential new ice growth. Later in the study a program will be designed and coordinated with other members of the science team who have utilized the ice classification algorithm to validate the functionality of the algorithm and to determine changes to the algorithm for improving accuracies, tracking of seasonal transitions, and replacing the scatterometer look-up tables with actual SAR-derived ice signatures.

**W93-70441****578-40-00**

Marshall Space Flight Center, Huntsville, AL.

**MODELING AND DATA ANALYSIS, PHYSICAL CLIMATE AND HYDROLOGICAL SYSTEMS, MODELING**

R. J. Koczor 205-544-3078

The objective of this RTOP is to conduct studies of atmospheric dynamics using numerical, experimental, and analytical models. Included are studies to examine baroclinic instability and its influence on the global circulation; diabatic processes affecting the thermodynamic energy budget; and the evolution of synoptic and planetary scale waves, including possible vacillation and/or scale interaction, with the objective of better defining the requirements for and applications of space-based sensor measurements. The approach will be to perform detailed analyses with theoretical models and ground-based data sets; to understand the role of latent heat release in the dynamics of cyclones; to examine global atmospheric processes to gain improved understanding of the scales of motion; to develop techniques for

including satellite data in diagnostic procedures; and to develop strategies and mission concepts to measure global scale processes from space platforms.

**W93-70442****578-41-01**

Goddard Inst. for Space Studies, New York, NY.

**GLOBAL CLIMATE MODELING**

James E. Hansen 212-678-5619

The objectives of this RTOP are to develop and apply climate models to support NASA's Climate Program, particularly carrying out basic research which helps define observing systems requirements for monitoring, analysis and prediction of long-range climate change. The approach is to develop climate modeling capability appropriate for analysis of long-range climate. Principal areas of model development are in the areas of moist convection and clouds, ground hydrology, surface-air exchanges, and numerical methods. The approach involves testing more realistic or accurate representations of these physical processes or numerical schemes, using the previously developed Model 2 as a control for these experiments. We plan to use the current Model 2 for climate studies aimed at obtaining a better understanding of global climate sensitivity and projections of transient climate change during the next 10 to 50 years. This includes experiments in which the global greenhouse forcing changes at a realistic rate on decadal time scales.

**W93-70443****578-41-43**

Goddard Inst. for Space Studies, New York, NY.

**AN OCEAN GENERAL CIRCULATION MODEL FOR CLIMATE STUDIES**

Inez Fung 212-678-5593

The objectives of this RTOP are (1) to investigate long time-scale natural variability in the climate system; (2) to investigate air-sea interaction in the North Atlantic; and (3) to reduce numerical diffusion in coarse-resolution ocean general circulation models. The major tool will be the global 3-D oceanic general circulation model (OGCM) developed by Bryan and streamlined at the Goddard Institute for Space Science (GISS). The model will be configured for sector geometry and run for greater than 1000 years with different off-line surface forcing to investigate internal modes of variation. The model will also be coupled to the GISS atmospheric general circulation model (GCM) to understand the ocean's role in natural climate variability. Surface exchanges of heat and fresh water will be re-examined using available conventional and satellite data and constrained by an inverse calculation and transports across 24 N. The surface fluxes will be compared with those derived from the atmospheric GCM to devise strategies for understanding and eliminating climate drifts in coupled models. Higher order finite-differencing schemes will be implemented in the OGCM to reduce numerical diffusion in the current model.

**W93-70444****578-42-15**

Goddard Space Flight Center, Greenbelt, MD.

**SUBGRID VARIATION OF SURFACE PARAMETERS**

David Toll 301-286-9256

The primary purpose of this research project is to examine subgrid-scale variations of the albedo, ground temperature, and surface heat fluxes using satellite data and available field observations. Case studies will use the resources from existing and future field programs (e.g., First ISLSCP (International Satellite Cloud Climatology Project) Field Experiment (FIFE), Hydrologic and Atmospheric Pilot Experiment (HAPEX), SPACE, BOREAS, etc.). The project will yield a number of scientific results that will lend insight into General Circulation Model (GCM) subgrid-scale problems and will provide work aiding in the application of existing parameterization schemes. The project results will quantify the measure of improvement that might be obtained when using selected procedures to estimate the subgrid effects. The results can also be used as guidelines for applying and developing parameterization procedures for planetary boundary layer parameters.



**W93-70445****578-90-00**

Marshall Space Flight Center, Huntsville, AL.  
**MODELING AND DATA ANALYSIS, CLIMATE AND  
 HYDROLOGY CRYOSPHERE STUDIES**  
 R. J. Koczor 205-544-3078

The objective of this RTOP is to perform fundamental studies aimed at improving our understanding of changes in the Earth's climate and hydrology. The approach of this RTOP will be to establish a coordinated modeling and data analysis program with NASA Headquarters, NASA Centers, and non-government research institutions.

**W93-70446****578-97-12**

Goddard Space Flight Center, Greenbelt, MD.  
**HYDROSPHERIC PROCESSES PROGRAM SUPPORT FOR  
 MODELING AND DATA ANALYSIS**  
 Antonio J. Busalacchi 301-286-6171

The objective of this RTOP is to support modeling and data analysis research activities in the Goddard Laboratory for Hydrospheric Processes.

**W93-70447****578-97-16**

Goddard Space Flight Center, Greenbelt, MD.  
**GRADUATE FELLOWSHIPS**  
 Franco Einaudi 301-286-6786

This program offers opportunities for graduate study in the Earth Sciences. Fellowships are awarded for one year and are renewable, based on progress, for up to three years.

**W93-70448****578-97-20**

Goddard Space Flight Center, Greenbelt, MD.  
**RADAR-ALTIMETER ICE DATA SYSTEM**  
 H. J. Zwally 301-286-8239

This RTOP covers the following topics: (1) processing of satellite radar altimetry data acquired over polar ice by the European Earth Resources Satellite-1 (ERS-1) and Topographic Ocean Experiment (TOPEX) satellites; (2) calculation and evaluation of various corrections; (3) compilation and validation of level 1 through 4 data sets of ice elevations and other parameters; (4) maintenance of a complete library of ice altimeter data and distribution of data to the scientific community; and (5) operation of a computer system for altimeter data.

**W93-70449****578-97-53**

Goddard Space Flight Center, Greenbelt, MD.  
**LTP VISUALIZATION**  
 Edward Masuoka 301-286-7608

The objective of this RTOP is to provide the best possible computing environment for scientists and staff who are managing research programs in Land Processes. The computing environment of the branch will be enhanced through the purchase of high performance computers for data analysis and image processing and networked peripherals for data storage. Additionally, the branch will be improved through maintaining a staff of UNIX system administrators and applications programmers who can assist users with hardware, software, and network problems.

## Biogeochemistry and Geophysics Modeling and Data Analysis

**W93-70450****579-22-00**

Ames Research Center, Moffett Field, CA.  
**THEORETICAL INVESTIGATION OF STRATOSPHERIC  
 PARTICULATES**

O. B. Toon 415-604-5971

The objective of the work is to contribute to NASA's

Atmospheric Chemistry Modeling and Analysis Program in the area of quantifying the importance of heterogeneous chemistry. A sophisticated model of polar stratospheric clouds has been developed and used to study the properties of ice clouds and nitric acid clouds. The model has been used to investigate the mechanisms of stratospheric denitrification. Also included is a meteorological support task to manage and distribute data from aircraft field programs. Meteorological data including conventional global analyses and forecasts, and satellite cloud imagery is supplied to the field programs via NASA internet links into a field local area network (LAN) and direct satellite downlink. The field mission data is archived and published on compact disk read-only memory (CDROM) for distribution to the field participants and the community.

**W93-70451****579-23-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**TWO-DIMENSIONAL STRATOSPHERIC CHEMICAL MODEL -  
 RADIATION**

D. Crisp 818-354-2224

The distribution of ozone and other important stratospheric trace gases is controlled by the coupled effects of chemical, dynamical, and radiative processes. A detailed description of each process is needed to diagnose the present state of the stratosphere and to assess the impact of natural and anthropogenic modifications to this system. The principal objective of this RTOP is to develop improved numerical radiative transfer models for finding solar heating rates, thermal cooling rates, and the diabatic circulation at these levels of the atmosphere. These models accommodate all radiative processes that are known to be important in the stratosphere, including absorption, emission, and multiple scattering by gases (H<sub>2</sub>O, CO<sub>2</sub>, O<sub>3</sub>, N<sub>2</sub>O, CH<sub>4</sub>, O<sub>2</sub>, SO<sub>2</sub>, NO<sub>2</sub>, and CFC's), aerosols, and clouds. The current radiative transfer model has provided benchmarks for the simpler radiative transfer algorithms that are used by other 2-D modeling groups, and has been used to generate net radiative heating rates for use in the Caltech 2-D chemical tracer transport model. It is currently undergoing major modifications to increase its speed, accuracy, and versatility. The original Voigt Quasi-Random Model is being replaced by a new class of methods called spectral mapping transformations (SMT's), that were developed as part of this program. Preliminary tests of this new method have demonstrated accuracies comparable to those of line-by-line models, and speeds like those obtained with simpler band models. Results from the new radiative transfer model will be incorporated into the Caltech/JPL 2-D chemical tracer transport model to support ongoing efforts to model stratospheric trace gases. The work supported by this RTOP is part of a continuing collaboration between investigators at Caltech (Y. Yung) and JPL (M. Allen and R. Zurek). A complete proposal for that work is in preparation.

**W93-70452****579-23-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**STRATOSPHERIC CHEMICAL MODEL: DYNAMICS**

R. W. Zurek 818-354-3725

The goals of this task are to use a range of models, including 2-D and 3-D interactive radiative-dynamic-photochemical models, and complementary diagnostic studies to understand quantitatively the coupled chemistry and transport of photochemically important atmospheric trace species, as revealed by various satellite remote sensors: Limb Infrared Monitor of the Stratosphere (LIMS); Stratospheric and Mesospheric Sounder (SAMS); Atmospheric Trace Molecule Spectroscopy (ATMOS); Improved SAMS (ISAMS); Microwave Limb Sounder (MLS); Cryogenic Limb Array Etalon Spectrometer (CLAES); etc. We propose to look at the 3-D aspects of transport and photochemical modulation of ozone during spring in the Antarctic and during winter in the Arctic. While the area-mapping technique removes many of the transient effects due to advection within, and evolution of, the polar vortex, both Total Ozone Mapping Spectrometer (TOMS) and Upper Atmosphere Research Sounder (UARS) Microwave Limb Sounder (MLS) data suggest that the photochemical destruction of ozone is not uniform within the vortex. The distribution and duration of



chemical species (e.g., ClO) involved in the catalytic destruction of ozone, and thus the total amount of ozone loss, depend upon the temporal and spatial evolution of the polar vortex (which can be monitored by computing potential vorticity), associated temperatures, and the total exposure to sunlight. We will use an existing 3-D stratosphere radiative-dynamic model formulated in isentropic coordinates and driven by forcing in the upper troposphere (greater than 350 K surface) to study the seasonal evolution and effects of transport within the polar vortices. Results using the model's transport equation will be compared with those using other developed advection schemes, including a modified version of the Prather scheme used in the existing Caltech/JPL 2-D model.

**W93-70453****579-24-00**

Ames Research Center, Moffett Field, CA.  
**SIMULATION OF TROPOSPHERIC OZONE**  
 R. B. Chatfield 415-604-5490

The objective of this program is to contribute to NASA's Atmospheric Chemistry Modeling and Data Analysis Program in the area of quantifying the effect of biomass burning and other emissions upon tropospheric radiatively active gases like ozone and methane, through computer simulation of these gases and associated gases that determine their levels. The approach is to construct, test, and apply one-, two-, and three-dimensional models of tropospheric trace species as they are photochemically transformed and transported away from their source regions. Emphasis is on large regional modeling and global-scale effects. The effort will be to construct the models, run the computer simulation models, and analyze the results for publication and comparison to remote-sensing and in-situ samples of tropospheric composition.

**W93-70454****579-24-06**

Goddard Inst. for Space Studies, New York, NY.  
**GLOBAL TROPOSPHERIC MODELING OF TRACE GASES**  
 David Rind 2120678-5593

The objectives of this RTOP are (1) to contribute to an understanding of global budgets for chemically and radiatively important trace gases and to an assessment of the human impact on atmospheric composition; and (2) to determine measurement requirements and sampling strategies for the tropospheric chemistry program, and to aid in interpretation of observations. A series of studies is being/has been made with a 3-D Chemical Transport Model (CTM) developed from the Goddard Institute for Space Science (GISS) General Circulation Model and in collaboration with colleagues at Harvard University. The approach has been progressive; successive studies of different chemical species have led to a better understanding and calibration of the CTM: (1) chlorofluorocarbons (Done); (2) krypton-85 (Done); (3) radon (Done); (4) methylchloroform (Done); (5) methane (Done); (6) carbon monoxide (in progress); and (7) odd nitrogen and ozone (in progress/planning).

**W93-70455****579-24-09**

Goddard Inst. for Space Studies, New York, NY.  
**CLIMATOLOGICAL STRATOSPHERIC MODELING**  
 David Rind 212-678-5593

The objectives of this RTOP are as follows: (1) contributions will be made toward understanding the impact of potential climate perturbations on the stratosphere; (2) assessment will be made of the effect of any alterations in stratospheric dynamics on the impact of anthropogenic releases on stratospheric ozone; and (3) a better understanding of the expected changes to be observed in the next several decades will be attempted. The approach will be 3-D modeling of the troposphere/stratosphere/mesosphere system to delineate climate change influence on the stratosphere; results are saved for use with photochemical models.

**W93-70456****579-31-01**

Goddard Space Flight Center, Greenbelt, MD.  
**PROBLEMS IN INTERPRETING SATELLITE CRUSTAL ANOMALY FIELD DATA**  
 Robert A. Langel 301-286-6603  
 (579-31-02)

The basic objectives of the program are to isolate crustal fields from the core and external fields and to model the isolated crustal fields in terms of geophysical parameters. This requires understanding the nature and limitations of satellite magnetic field data, collection of and comparison with data from aeromagnetic and ship magnetic surveys, and evaluation of the effects of external fields. Consequences of satellite data limitations for interpretation are to be discovered. The approach consists of (1) the development of suitable data selection and filtering criteria, (2) estimating or modeling external fields and correcting the data where possible, (3) collecting and collating alternative data for comparison and joint analysis, and (4) developing and evaluating analysis techniques.

**W93-70457****579-31-02**

Goddard Space Flight Center, Greenbelt, MD.  
**MODELING OF THE MAIN MAGNETIC FIELD**  
 Robert A. Langel 301-286-6603  
 (579-31-01)

The major objectives of this RTOP are to develop improved methods and techniques for the analysis and determination of the geomagnetic field and its temporal change; to test those methods and techniques by derivation of models of the Earth's field and its temporal variation; and, as appropriate, to use the resulting models to study the processes in the core which are responsible for generation of that field and the conductivity of the mantle through which the time varying field passes. For focus, the specific research goal for FY-92 to FY-94 is to derive a definitive model of the geomagnetic field for the period 1900 through 1992, including representation of low degree external terms and including an error model. The research will proceed along three directions simultaneously: (1) development of data weighting and error model; (2) extension of external field representation; and (3) investigation of parameterization of temporal change. In error analysis, methods proposed for dealing with the presence of crustal and external fields will be compared, evaluated, and, as appropriate, implemented. A better understanding of the statistics of crustal and external fields will be pursued both theoretically and by analysis of the spectral properties of aeromagnetic and marine magnetic data. Existing error formalisms will be extended. The currently used method of setting the external spherical harmonic coefficients proportional to the Dst index will be extended to use either sunspot number or the aa index in place of Dst, permitting extension of the method to earlier epochs when Dst is not available. The appropriate degree and order of external terms will be re-examined. Three alternative approaches to the usual Taylor series will be explored. The first is strictly mathematically based and uses spline functions. The second and third are based on theories of the generation of the geomagnetic temporal variations. In the second case, the assumption that the fluid flow at the core-mantle boundary (CMB) is steady is utilized to derive a formalism in which the solution includes the coefficients in spherical harmonic representations of the fluid flow itself. In the third case, Braginsky's theory of Alfvénic torsional oscillations is assumed to result in temporal change dominated by periodic behavior (i.e., the geomagnetic Gauss coefficients will be assumed to be periodic). Decade variations in length of day changes are ascribed by Braginsky to the same phenomena and are used to define the appropriate periods.

**W93-70458****579-31-07**

Goddard Space Flight Center, Greenbelt, MD.  
**GEOMAGNETIC MODELING OF CORE FLUID MOTIONS**  
 Coerte V. Voorhies 301-286-3530  
 (579-31-02)

The objective is to improve quantitative explication of global geomagnetic secular change in terms of its origin as an imbalance

between motional induction and magnetic diffusion near the top of Earth's electrically conducting liquid outer core and the diffusion of this signal through the rigid, electrically resistive mantle. Technical objectives are to: (1) improve steady core surface flow estimates by allowing for mantle conductivity, core asphericity, and an uncertain initial magnetic field; (2) estimate deep mantle conductivity; and (3) study slowly varying core surface flow. The approach is to derive steady core surface flows from the Definitive Geomagnetic Reference Field (DGRF) models (IAGA, 1988) for several mantle conductivity profiles using damped, weighted least squares. We seek the profile giving the best fit at a fixed, modest level of flow complexity. We plan derivation of both an initial core field model and a steady flow. Preliminary results should be ready by the start of FY-93. The initial field and flow are to be derived from the data, rather than DGRF models. Slowly varying core flow estimation is to be pursued after corrections for core asphericity.

**W93-70459**

Goddard Space Flight Center, Greenbelt, MD.

**CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)**

Carey E. Noll 301-286-9283

The Crustal Dynamics Data Information System (CDDIS) continues to fully support the data archiving and distribution requirements of the Crustal Dynamics Project (CDP) through December 1991. At that time, the CDP formally comes to an end and its successor, the Dynamics of the Solid Earth (DOSE) begins; the CDDIS continues to support DOSE in a similar fashion. The CDP was formed by NASA to apply space methods and technology to advance the scientific understanding of Earth dynamics, tectonophysics, and earthquake mechanisms. The Project uses three types of space-age techniques in this study: laser ranging to an artificial satellite or the moon, very long baseline interferometry (VLBI), and the global positioning system (GPS). As part of its data management, the Project has designed and implemented a centralized CDDIS. The CDDIS began operation in Sep. 1982. The main purpose of the CDDIS is to store all geodetic data products in a central data bank and maintain information about the archival of these data. The CDDIS is also tasked to disseminate these data products to Project investigators and cooperating institutions. The laser, VLBI, and GPS data sets accessible through the CDDIS fall into four major categories: preprocessed (Level 1), analyzed (Level 2 and 3), ancillary, and Project management data. The CDDIS is operational on a DEC Micro VAX II computer with nearly two Gbytes of on-line magnetic disk storage and 650 Mbytes of on-line optical disk storage (additional Gbytes are near-line); this system was upgraded to a VAX 4000 in fiscal year 1992 (FY-92). The CDDIS is accessible to all investigators from remote, worldwide locations through the NASA Science Internet (NSI)-DECnet, NSI-Transmission Control Protocol/Internet Protocol (TCP/IP), and BITnet networks, through GTE SPRINTnet, and through dial-in service.

**W93-70460**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**EARTH ROTATION AND MANTLE STRUCTURE**

C. F. Yoder 818-354-2444

This RTOP is intended to support general scientific research related to interpretation of Crustal Dynamics Project (CDP) earth orientation data (universal time, polar motion and nutation) and Lages orbit perturbations, particularly the secular changes J2, J3, J4, etc. A layered earth model has already been developed to examine how viscosity structure and melting history affect present day changes in gravity field. A composite rheology model has been constructed which exhibits transient relaxation and which may be a reasonable model for the spherically symmetric component of mantle heterogeneity. A model describing the lateral dependence on viscosity structure shall be developed which uses the tomographic lateral velocity variations to infer temperature viscosity variations. The principal objective is to determine how well observables, such as the secular change in J2, and polar motion constrain viscosity structure. The second topic concerning earth rotation is the construction of a more complex semi-analytic

nutation model which takes into account oceans, solid friction, and earth model uncertainties. In addition, the effect of the inner core, core-mantle boundary layer, 'figure-figure' core mantle coupling and the non-hydrostatic gravity field shall be examined. The principal objective for this task is to determine how well nutations constrain the core-mantle ellipticity, solid friction, Q, and earth structural models. Finally, mechanisms which could account for non-tidal changes in universal time of order 200 sec on millennia time scales shall be examined.

**W93-70461**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GEOPHYSICAL ANALYSIS AND MODELING OF LLR DATA**

J. G. Williams 818-354-6466

The analysis of the lunar laser range data is intended to determine parameters of geophysical and geodetic interest as its final product. These parameters are station locations, their rates, earth rotation, gravitational coefficient (GM) of the earth, tidal acceleration of the moon, nutations, and the rate and pole of the precession of the earth in space. These determinations will contribute to precision geodesy and the understanding of plate motion, solid body and ocean tides, the moments of inertia of the earth, and the earth's interior structure. The continued processing of lunar range data will improve upon the accuracies of these determinations as newer, more accurate ranges are received. The software needs improvements at the 1 to 2 cm level to fully use the 3 cm accuracy of the ranges being received from all three stations. Principal among these improvements are changes in the tidal displacements of the stations for variable Love numbers, solid body pole tide, and ocean loading. Also needed are rapid (diurnal and semidiurnal) ocean-tide driven earth rotation terms and the ability to solve for out-of-phase terms at one-half and one month. Also intended are upgrades in the software for operational efficiency. Published or submitted are results on precession, nutations, the earth's GM, and the tidally driven lunar secular acceleration. Other solutions have given a new value of the earth's GM. Earth rotation results have been submitted to the International Earth Rotation Service.

**W93-70462**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**RAPID EARTH ORIENTATION CHANGES**

J. O. Dickey 818-354-3235

The rotation vector of the solid Earth exhibits complicated changes in both magnitude and direction over a broad spectrum of time scales, reflecting the influence of a wide variety of geophysical and astronomical phenomena. Our objective is to observe and define the interactions of the atmosphere and oceans with the rotational dynamics of the solid Earth (crust and mantle), in order to understand their contributions to the excitation of both length-of-day (LOD) and polar motion fluctuations. Our approach will involve detailed comparisons of space geodetic determinations with complementary geophysical data, including general circulation models (GCMs) of the atmosphere and oceans. We plan to utilize the existing Earth orientation data, especially those from the NASA Extended Research and Development Experiment held in 1989, the Global Positioning System (GPS) GPS IERS Geodynamics (GIG) results from 1991, and those from the planned International Earth Rotation Service (IERS) campaign in 1992. In addition, we will analyze six hourly atmospheric angular momentum values derived from data collected during the First Global Atmospheric Research Program Global Experiment (FGGE) period, as well as results from the four operational centers (National Meteorological Center, European Center, U.K. Meteorological Office, and Japanese Meteorological Agency).

**W93-70463**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**CORE-MANTLE EXCITATION**

R. S. Gross 818-354-4010

The fundamental objective of this study is to gain greater understanding of the characteristics and origin of the observed decadal fluctuations in the Earth's rotation and polar motion. This

will be accomplished by deriving improved long term Earth rotation series, and then interpreting them in terms of possible geophysical excitation mechanisms such as core-mantle coupling and the cumulative effect of great earthquakes. The individual and cumulative coseismic effects of earthquakes on other global geodetic properties of the Earth will be studied as well. We will study both the long term (century) and short term (decade) changes that occur in these properties, as well as their interrelationships. We will investigate core-mantle coupling and its excitation of Earth rotation and polar motion using a multi-faceted approach. The observed length-of-day and polar motion series and the inferred three-vector torque will provide strong constraints on both core-mantle coupling mechanisms currently being considered (electromagnetic and topographic), thereby improving our understanding of the core-mantle interaction and its excitation of decadal changes in length-of-day and polar motion. For earthquake excitation, our approach will be to first compute the earthquake-induced deformation field of the spherically symmetric, non-rotating, elastic, isotropic (SNREI) Earth model 1066B by expanding the deformation field as a weighted sum of the normal mode eigenfunctions of 1066B. For this calculation we will use two different earthquake source mechanism data sets, namely: (1) the centroid-moment tensor solutions being routinely determined and published by the Harvard Group for all earthquakes having seismic moment  $M(\text{sub } 0)$  greater than  $10(\text{exp } 24)$  dyne-cm; and (2) the source properties for the greatest  $M(\text{sub } 0)$  greater than  $10(\text{exp } 28)$  dyne-cm earthquakes to have occurred since 1900 that have been determined and published in the publicly available literature. We will then determine the effect that these earthquakes have had on: (1) the secular drift of the Earth's rotation pole; (2) polar motion; and (3) the Earth's shape as measured by changes in baseline lengths and orientations.

**W93-70464****579-41-00**

Ames Research Center, Moffett Field, CA.

**IMAGE PROCESSING LABORATORY FOR TERRESTRIAL ECOLOGY**

K. J. Weinstock 415-604-3327

The objective of this work is to provide general support to NASA's science program in Terrestrial Remote Sensing. This RTOP will insure that supplementary support is provided for the operation of Ames Research Center's (ARC) Image Processing Laboratory (IPL) and will contribute toward development of new capabilities for the analysis of remote sensing and ecological data by incoming senior scientists. The approach will be to provide support to the IPL in the form of funding for ongoing computer equipment replacement and upgrades and for one-time additions of specific state-of-the-art equipment.

**W93-70465****579-41-04**

Goddard Space Flight Center, Greenbelt, MD.

**LTP COMPUTER SUPPORT**

Edward Masuoka 301-286-7608

The objective is to provide the best possible computing environment for scientists in the Laboratory for Terrestrial Physics, who are conducting research in Land Processes. The following approaches will be used: (1) create a powerful computing environment in the Laboratory computer facility by integrating UNIX workstations into the VAXcluster as computer and file servers and image analysis stations; (2) provide system administration and networking support for scientists with UNIX workstations; (3) improve analysis capabilities of existing workstations by providing programmer support to assist scientists working with a common suite of software for graphics and image processing; and (4) operate a VAX mini-computer to support scientists working on the First ISLSCP Field Experiment (FIFE) and BOREAS project.

**W93-70466****579-41-08**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ERS-1 STUDIES OF FOREST ECOSYSTEMS**

J. B. Way 818-354-8225

(462-41-61)

Multitemporal measurements of forest ecosystems may be

critical in resolving ambiguous interpretations of microwave backscattering from architecturally complicated forest canopies in the presence of spatial and temporal variability in scene characteristics. It is postulated that multitemporal microwave observations can be utilized to separate weather related scene variance from phenologic development. In addition, changing seasonal environmental conditions enhance or subdue certain components of the radar backscatter. The primary objective of this effort is to collect, calibrate, and analyze the ESA Remote Sensing Satellite-1 (ERS-1) and Japanese Earth Resources Satellite-1 (JERS-1) image data to be used in studying temporal change (phenologic and environmental) in forest ecosystems. A related RTOP (462-41-61) under Dr. Diane Wickland's program addresses the collection of associated ground truth and modeling of the canopy data to predict multi-seasonal radar backscatter signatures. To address the above questions, we are using multi-season ERS-1, JERS-1, and AIRSAR data sets of sites in the U.S. including the Bonanza Creek Experimental Forest in Alaska, the Duke University Research Forest in North Carolina, and the Michigan Biological Station in Michigan. Ground truth measurements collected simultaneously with the aircraft and satellite data are being used in conjunction with existing radar models to determine which of the canopy properties are contributing to the backscatter at all wavelengths and polarizations. To date, freeze-thaw, stress from frost, drought, and flooded conditions were obtained in Alaska, summer drought stress and flooded conditions were obtained over Duke, and winter snow and summer rain/no-rain data sets were acquired over Michigan with AIRSAR. Approximately 50 ERS-1 scenes were obtained over both Michigan and Alaska between summer and winter of 1991. Additional data sets will be acquired through 1994.

**W93-70467****579-42-01**

Goddard Space Flight Center, Greenbelt, MD.

**BIOGEOCHEMISTRY AND GEOPHYSICS MODELING AND DATA ANALYSIS**

William K.-M. Lau 301-286-7208

The objective of this RTOP is to analyze the variability and response of the atmosphere to boundary forcings and examine different aspects of land-atmosphere interactions. This approach will conduct a ten year simulation with the new 17-layer model under AMIP project and use the times series of this run to analyze atmospheric response.

**W93-70468****579-42-02**

Goddard Space Flight Center, Greenbelt, MD.

**MODELING AND MULTISPECTRAL SATELLITE DATA ANALYSIS FOR LAND SURFACE STUDY WITH SPECIAL EMPHASIS ON HOT ARID AND SEMI-ARID REGIONS**

Bhaskar J. Choudhury 301-286-5155

(461-13-01)

The objective of this RTOP is to quantify seasonal and inter-annual variations of surface wetness, temperature, microwave polarization difference, and spectral vegetation indices over hot arid and semi-arid regions of Africa and Australia for the period 1979 to 1990 using the Scanning Multichannel Microwave Radiometer (SMMR), the Advanced Very High Resolution Radiometer (AVHRR), the Thematic Mapper (TM), and the Special Sensor Microwave/Imager (SSM/I) data. Radiative transfer and heat balance simulations will be performed to understand this data in terms of land surface prognostic and diagnostic variables. A predictive model for surface wetness will be developed based upon SMMR 6.6 and 37 GHz data and tested over an independent region within the U.S. Southern Great Plains. The effort will be made to use the SMMR data to produce soil moisture maps for Africa and Australia for 1979 to 1990. Radiative transfer and heat balance models will be developed to use daily or monthly meteorologic data acquired from the National Climate Center to simulate reflectances, vegetation indices, and surface temperature. Methodology for correcting the satellite data for atmospheric effects will be developed. SSMR and SSM/I 37 GHz data will be compared. The simulated relations between the multispectral data will be

compared with the observed relations to evaluate the relative sensitivity to varied surface and environmental characteristics.

**W93-70469****579-42-03**

Goddard Space Flight Center, Greenbelt, MD.

**TOPOGRAPHY FROM SEASAT AND GEOSAT OVERLAND ALTIMETRY**

Herbert Frey 301-286-5450

The objectives of this RTOP are as follows: to determine the accuracy, quality, and utility of topographic data derived from the Specialized Experimental Applications Satellite (SEASAT) and the Geodetic Satellite (GEOSAT) overland altimetry on a local, regional, and global basis; to develop techniques to selectively combine data from SEASAT and GEOSAT overland altimetry; and to demonstrate utility of satellite-derived topographic data for geological, geophysical, and hydrological problems, including monitoring seasonal changes in river levels. The approach will be as follows: to develop automated approaches to selection of GEOSAT repeat data over rivers for monitoring water level over time; to compare results with river gauge data in a blind test; to combine GEOSAT and SEASAT data in selective regions to produce a ten-year record of height changes; to evaluate the accuracy of these by detailed comparison of the profile data with existing high quality topographic contour maps produced locally for each continent; to produce contour maps for each continent along with maps showing the quality of the mean values derived for each grid point; and to assess the utility of the satellite-derived data for regional geophysical problems such as the mechanism of compensation of the Himalayas, and for geological problems such as the differences between ancient and modern stream gradients in the 'Trans-African Drainage System', water level change in ephemeral lakes, and uplift of shorelines due to post-glacial rebound.

**W93-70470****579-42-11**

Goddard Space Flight Center, Greenbelt, MD.

**SATELLITE DATA SETS AND ALGORITHM TESTING**

Donald W. Deering 301-286-9186

The objective is to develop and test techniques for extracting biophysical and other parameters related to land surface climatology on two continents. Ground and aircraft data are acquired as ground truth during intensive field campaigns coincident with satellite overpasses. The satellite data sets are acquired, processed, and analyzed to evaluate for the new study regions, as are algorithms that have been developed through research at other sites. Modifications are developed as required for the new areas.

**W93-70471****579-42-13**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SOIL/CANOPY MOISTURE AND TEMPERATURE PROFILES USING REMOTE SENSING AND MODELING**

E. G. Njoku 818-354-3693

The problem of retrieval of soil and canopy moisture and temperature profiles using passive microwave remote sensing is addressed by means of a unified remote sensing/modeling approach. Characterization of the seasonal moisture and temperature variations of the soil-canopy system is important for diagnostic analyses of regional climates and in the validation of general circulation models. Relations are developed for microwave radiative transfer through vegetation and soil. A state-space model is developed for heat and moisture flux in the soil-canopy system. These models are combined into a statistically optimal assimilation algorithm that uses remote sensing observations on portions of the system (namely the near-surface soil and vegetation) to update the state-space prediction of the soil-canopy profiles. The procedure is tested using simulated observational data and data from in situ, aircraft, and satellite instruments. The procedure initially emphasizes passive microwave observations but may be extended to include active microwave, visible, and infrared observations. The work in this RTOP is performed in collaboration with D. Entekhabi (Co-Principal Investigator) of the Massachusetts Institute of Technology.

**W93-70472****579-43-00**

Ames Research Center, Moffett Field, CA.

**SPATIAL AND TEMPORAL DISTRIBUTION OF BIOMASS COMBUSTION AND PYROGENIC TRACE GAS EMISSIONS**

J. A. Brass 415-604-3329

(463-67-08; 463-67-10)

The goal of this research is to develop and test methods of estimating fire extent and resultant seasonal and annual fluxes of trace gases at a regional scale, and to assess the relative impact on the atmosphere of biomass burning in several tropical ecozones. Our approach includes the following components: geographic stratification to define ecozones; analysis of comprehensive Advanced Very High Resolution Radiometer (AVHRR) and selected Thematic Mapper (TM) imagery of the Brazilian cerrado; and use of trace gas emissions data from other researchers. Fire activity products will be produced as a detailed intermediate product to be used for estimating gas emissions and as published information for other projects which investigate the impact of biomass burning at regional to global scales. Regional gas emissions over the annual fire season will make it possible to determine the role of tropical budgets of such gases as methane. Experimental products of weekly estimates at 1 degree will be produced as input for models of tropospheric chemistry currently under development.

**W93-70473****579-82-00**

Ames Research Center, Moffett Field, CA.

**BIBLIOGRAPHY FOR LAND PROCESSES PUBLICATIONS**

J. G. Lawless 415-604-5900

The objective of this work is to provide a bibliography to Headquarter's Earth Science and Applications Division that will document the peer-reviewed publications produced as a result of NASA's Land Processes Research Program (1984 to date). This bibliography will be used to determine the impact of the program and will be used by managers and scientists to identify articles of interest and trace the history and contributions of land processes research.

**W93-70474****579-82-90**

Goddard Space Flight Center, Greenbelt, MD.

**COMPUTER AND INFORMATION SYSTEMS SUPPORT**

Edward Masuoka 301-286-7608

The objective is to provide the best possible computing environment for scientists and staff who are managing research programs in land processes. The computing environment of the branch will be enhanced through the purchase of high performance Apple Macintosh computer systems for data analysis and image processing and networked peripherals for data storage and the production of high quality color output.

**W93-70475****579-97-00**

Ames Research Center, Moffett Field, CA.

**GLOBAL CHANGE**

J. G. Lawless 415-604-5900

The objective of this work is to provide general support for Ames Research Center (ARC) participation in NASA's Mission to Planet Earth Component of the Nation's Global Change Program. This RTOP will be used to provide support for planning a collaborative consortium of public and private institutions and agencies in California and the West. The approach will be to provide support for producing a final management plan and workshops as necessary to produce the science proposal for the consortium. In addition, the interface to efforts proposed by the Aspen Global Change Institute will be developed.

**W93-70476****579-98-00**

Ames Research Center, Moffett Field, CA.

**LANDSAT LAND COVER PATHFINDER**

E. J. Sheffner 415-604-6565

The Landsat Land Cover Pathfinder is one of five elements in the Pathfinder Program of the National Aeronautics and Space Administration (NASA). Pathfinder was developed as part of NASA's response to the U.S. Global Change Research Program. The objective of Pathfinder is to make archived data from satellite-borne

sensors applicable to global change research, and similar data currently being collected by operational satellite systems, accessible to the user community in formats and at costs that will stimulate global change research in the era prior to the launch of the first Earth Observing Satellite. The Multispectral Scanner System on the Landsat satellites has the longest continuous archive (twenty years) of global data of any satellite sensor. To make better use of this data, the Agency has formed the User Working Group. The function of the group is to provide guidance options to the Agency on how best to exploit the Landsat data base, especially what products to generate from the data base, how to disperse products to the science community and other users, and to define significant global change science issues that can be addressed by the data set. The Agency, and its cooperators, are also seeking support to perform research with the Landsat Pathfinder data.

## Data Systems

**W93-70477** **656-50-65**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **INFORMATION SYSTEMS NEWSLETTER**

S. L. Dueck 818-354-5073

The purpose of the Information Systems Newsletter is to inform the Space Science and Applications Research and Science community about Information Systems development and to promote coordination and collaboration between NASA offices and NASA centers by providing a forum for communication on a quarterly basis. The Information Systems Newsletter is produced quarterly and focuses on programs sponsored by the Information Systems Branch in support of the Office of Space Science and Applications and includes articles of interest from other programs and agencies. Collaborative and coordinated Information Systems Branch programs are encouraged by developing mechanisms and plans for coordination at specific Information Systems meetings and at related workshops, conferences, and meetings. Technical and policy review are provided by JPL's Office of Space Science and Instruments by NASA Headquarters. New techniques for distributing information about the NASA activities are evaluated, and included wherever possible.

**W93-70478** **656-61-02**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **DATA SYSTEM INTEGRATION (COMMONALITY AND INTEROPERABILITY)**

L. E. Preheim 818-306-6042  
(656-61-03)

Data Archive Systems for both the evolution of existing disciplines and the development of new discipline archives (Life Sciences, Micro-gravity and Space Physics) support many similar functions for data ingestion, identification, storage, access and distribution. The functional overlap provides an opportunity for significant cost savings, functional enhancement and risk reduction if the 'best' building blocks from each discipline can be shared among all. The primary purpose of the Data System Integration Task is to provide support for the use of reconfigurable system building blocks (proven software modules) across Office of Space Science and Applications (OSSA) disciplines. A second objective of this task is to promote the sharing of experience and improved communication among OSSA disciplines. The experiences of the OSSA Discipline Data Systems (PDS, ADS, EOS, etc.) provide invaluable guidance to other disciplines, both emerging and existing. Examples of topics which deserve broad discussion across the community include (1) which technologies are under study, (2) which have been phased out, (3) how interoperability challenges are being met, and (4) what management structures work and why. Promoting interoperability is the third objective of this task.

The call for smaller, more cost effective missions places challenging requirements on mission data systems. They must be built quickly, inexpensively and for many, must interoperate with existing discipline systems. Reusable system building blocks are seen as a key element in data system interoperability. The key to fostering use/reuse of building blocks is to show the benefit of each in an environment which is operational, similar to the users' and demonstrates portability and maturity of the block. Understanding the driving requirements, emerging solutions and how they may be applied is the fourth objective of this task. OSSA disciplines have developed or are developing discipline specific archives responding to the needs of discipline supported researchers. Developing multidisciplinary archives to support investigators asking questions requiring access to heterogeneous data archives is a new necessity for NASA.

**W93-70479**

**656-61-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **DATA INTERCHANGE STANDARDS**

J. Grimes 818-354-3890

(155029049; 656-61-02)

The purpose of this RTOP is to develop standard methods for organizing (grouping) and identifying information with the long-range objective of facilitating automated, generic services, and of providing a means to permanently describe data to avoid its loss. As part of the RTOP, a Control Authority registers identifiers for formats and data description languages, preserving and disseminating these definitions. This helps contemporary or future users of the data to have recourse to the definitions even when those organizations of persons generating the data are no longer available to consult. The work is based on the 'Standard Formatted Data Unit (SFDU) Concept', a technique under development by NASA in cooperation with 22 other space agencies of the world who are part of the 'Consultative Committee for Space Data Systems' (CCSDS). Previous work has developed the necessary concepts and basic standards; the RTOP this year will refine these concepts and extend the standards in accordance with projects' needs. In addition, it focusses on (1) understanding the SFDU System environment and architecture at JPL, NASA, and internationally, and (2) the development of standard software tools to provide services for users working with SFDU's and other activities directly in support of projects at JPL. The effort is divided into the following major areas: (1) SFDU System Engineering: Participate, with CCSDS, in the definition of the SFDU system architecture and requirements, and in the establishment of standards based on that architecture, perform system engineering tasks including requirements and test definition for the phase 2 SFDU toolset, and provide user support and feedback to SFDU developers (e.g., application engineering support for first-time implementors of the SFDU concept such as Mars Observer (MO), Magellan (MGN), Topographic Ocean Experiment (TOPEX), National Ancillary Information Facility (NAIF), Planetary Data System (PDS), etc.); (2) Continue the development of standard portable S/W tools for creating, manipulating, displaying, and managing SFDU products, and provide support to SFDU System Engineering by means of prototype information system development of advanced CCSDS Concepts; and (3) Develop and provide at JPL Control Authority services, including interfaces with data registrants and with other Control Authorities.

**W93-70480**

**656-61-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **NAVIGATION ANCILLARY INFORMATION FACILITY (NAIF)**

C. H. Acton 818-354-3869

(155-20-40)

This RTOP develops and tests prototype software and data management technology, collectively called the Survey Probe Infrared Celestial Experiment (SPICE) system, that is used to facilitate the preparation, archiving, distribution, and user access to navigation and related ancillary geometry information required to obtain a full understanding of the science data returned from space-borne instruments. Accommodation is made for requirements that pertain to planning such observations, and for assisting with

engineering aspects of mission operations. The work is conducted in direct response to recommendations of the National Academy of Science's Committee on Data Management and Computation. It is particularly relevant as instrument complexity, instrument data volume, and interest in correlative analyses grow. The work supports the objectives of improving the interpretation of space science data while also reducing the OSSA-wide cost for production and use of necessary ancillary data through multimission and multidiscipline applicability. The National Ancillary Information Facility (NAIF) development approach follows recommendations to keep the space science community involved in all stages of SPICE development, including providing prototype component capabilities to scientists for evaluation in conjunction with ongoing research. With a major role in supporting flight project operations, NAIF must ensure that the SPICE standards and methodology are consistent with those of the relevant discipline data systems.

**W93-70481** **656-61-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**PDS: DATA DISTRIBUTION AND ARCHIVE TECHNOLOGY**

S. K. McMahon 818-360-6040  
(155-20-40)

The overall objective of this RTOP is to improve data distribution plus archive technology and methods for science data systems. It uses the Planetary Data System (PDS) as the initial testbed, but the technology and methods developed are applicable to data systems of all disciplines. There are two parts to this RTOP, labeled as A and B below. The objectives of Part A are to continue the Data Distribution and Archive Lab at JPL. This facility will do the following: (1) provide assistance to the PDS and other NASA programs in distributing new or existing data sets on CD-ROM disks; (2) develop or adapt a basic set of software tools for preparing and accessing data sets distributed on CD-ROM; (3) continue to develop the Distributable Data System Concept, where CD-ROM's contain full sets of documentation, catalog, geometry, software, and data; and (4) evaluate optical and magnetic data storage media for both data distribution and data systems. As a complement to the technology enhancement objectives, an equally important objective, Part B, is to improve the methods of how the Office of Space Science and Applications (OSSA) plans for and actually transfers mission archive data into long term archives, especially attacking the problems posed by: (1) very large data volumes; and (2) transfers from the flight projects with distributed data systems. The approach used for Part A will be to support PDS data preservation work. It will also coordinate with and support archiving efforts of other data systems (National Space Science Data Center (NSSDC), NASA Ocean Data System (NODS), Multimission Image Processing Laboratory (MIPL), FIST, SAR, etc.) to avoid duplication of effort. All tools will be developed to run on off-the-shelf computers (PC, Mac, Vaxstation, Sparcstation) to allow wide distribution and utilization by the science community. The approach for Part B will be to improve the methods for science data archiving. The approach is to plan and prototype large volume and electronic science/catalog transfer techniques using current standards and actual flight project data and teams. Lessons learned from the prototyping on risk avoidance and cost reduction will be passed on to other discipline archive systems.

**W93-70482** **656-61-07**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SCIENCE DIGITAL DATA PRESERVATION**

S. LaVoie 818-354-5677  
(186-00-00)

The objectives of the RTOP are as follows: inventory and evaluate all tapes (135,000); preserve valuable data currently residing on 50,000 tapes and make the data more accessible to the user; further reduce the volume of tapes by converting to a higher density media and disposing of duplicate data; and transfer converted tapes and archive responsibility to the appropriate archive facilities. The approaches are as follows: (1) Phase 1 - Inventory and Evaluation (begun in FY-90; will be completed end of FY-92) - recall all tapes; organize, inventory, and catalog tapes; evaluate tape value under guidance of Science Data Evaluation

Board (representatives from science and technical community knowledgeable about the data), Planetary Data System, and Planetary Science Data Steering Group (PSDSG); prepare valuable data for conversion; distribute or dispose of duplicate data; publish Phase 1 report; evaluate conversion alternatives for both archive media and hardware/software approach (in preparation for Phase 2); and publish Draft Conversion Plan and Schedule; and (2) Phase 2 - Conversion (begin FY-93) - establish data set conversion priorities relevant to existing inventories of Solar System Exploration data sets; convert all valuable data to higher density media; generate catalog of tape contents; transfer tapes and archive responsibility to Planetary Data System or appropriate JPL or NASA facility, National Space Science Data Center (NSSDC) and JPL Archives; and publish task final report.

**W93-70483**

**656-61-13**

Goddard Space Flight Center, Greenbelt, MD.

**SS FREEDOM ARCHIVE PLANNING STUDY**

Joseph H. King 301-286-7355

This RTOP started as an assessment of the optimal roles for National Space Science Data Center (NSSDC) in the management and archiving of data from life science and microgravity missions. Workshops held, with co-sponsorship by the Life Science and Microgravity Divisions at Headquarters/Office of Space Science and Applications (OSSA), and workshop reports, including recommendations, were issued. For both disciplines, Discipline Data Systems are being developed outside NSSDC, with some NSSDC consulting. In addition, a Discipline Data Systems Lessons Learned Document was created, capturing the experience of extant OSSA Discipline Data Systems.

**W93-70484**

**656-61-17**

Goddard Space Flight Center, Greenbelt, MD.

**NSSDC ASTROPHYSICS DATA SYSTEMS SUPPORT**

Michael E. VanSteenberg 301-286-7876  
(399-30-00)

The purpose of this project is the continued development and utilization of technologies that help the National Space Science Data Center (NSSDC) support the Astrophysics Data System (ADS) effort. The scope of this RTOP is divided into three parts: (1) Generic On-Line Data Access/Distribution Tools; (2) Generic On-Line Documentation/Literature Tools; and (3) Application of Generic Tools as ADS Services. In the first facet we plan to provide additional generic software tools, either through complete development or re-use of existing tools from outside sources (i.e., Code R AI developments or general scientific community produced code), that will enable the general scientist to stage or promote data from near- and/or off-line status to on-line status; examine or browse data that has been staged; and extract or subset data for distribution. In the second facet we plan to develop generic software and hardware tools that will support digitization of textual data (dataset documentation/literature); maintenance and storage of digitized textual data using existing facilities; searching, examination, and browsing of the textual data (image and text); integration of distribution by request through existing facilities; and on- and near-line access to pertinent textual data. In the third facet we will install the tools developed in the above. In particular, we will establish services at the NSSDC ADS node which include data selection, staging, browsing, and extraction for the Astronomical Data Center (ADC) on-line catalogs; the National Space Science Data Center (NSSDC) held archival data; and access to electronic on- and near-line documentation and literature.

**W93-70485**

**656-61-18**

Goddard Space Flight Center, Greenbelt, MD.

**SPACE PHYSICS DATA SYSTEM**

R. E. McGuire 301-286-7794

A primary goal of NASA space science missions is the collection and analysis of scientific data. Often, however, the handling of flight project data has been an 'afterthought' lost in the press to successfully build and fly new instruments and to make the first and most exciting of the new discoveries always



present in such observations. But the data are generally of much longer term importance and require appropriate attention to their archive, management and ongoing research accessibility. Recent experience in the NASA science community strongly suggests that a discipline-oriented data system can significantly enhance the ability to best manage these data products. This multi-year RTOP is to support the definition, design and prioritized implementation of appropriate elements of a Space Physics (discipline) Data System (SPDS). The system is envisioned to be highly distributed and will attempt to make maximum possible use of existing capabilities and facilities. Because the detailed long-term requirements and implementation plans of SPDS are still under definition, the work to be done under this RTOP has at this time three broad goals: (1) to support the definition of SPDS and its implementation plan; (2) to pursue specific efforts at an overall 'system' level on behalf of SPDS; and (3) to pursue specific (primarily data-oriented) products for eventual inclusion into SPDS.

**W93-70486****656-61-20**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**PLANETARY HARDCOPY PRESERVATION TASK**

L. J. Pieri 818-354-8320

(656-61-07)

Much planetary flight project data exists in a variety of hardcopy media (film, printer paper, computer listings, drawings, photographic paper, plots, etc.). These data are produced during the active mission phases, but are valuable in a post-mission analysis phase. It is important to ensure the preservation of these products for long-term science community access. The objectives of this RTOP are (1) the proper identification, evaluation, disposition recommendations, handling and storage techniques, reproduction and/or appropriate media conversion for these hardcopy products; and (2) preservation of valuable hardcopy planetary data for use by the planetary science community. This effort will examine and assess planetary data products from the Voyager Imaging Library and other JPL post-mission collections housed in the JPL Regional Planetary Image Facility; coordinate with the PDS and the SDDRT activity to establish general priorities, products which should be disposed of, adequately stored in the current media for long term preservation, or converted to a different media or reproduced/restored; recommend, based on research and coordination with other institutions concerned with the preservation of hardcopy products, application of adequate storage techniques or conversion techniques; and ultimately ensure product life through media conversion, adequate storage methods or reproduction. FY-92 deliverables focused on contacting members of the planetary community and familiarizing them with the task and obtaining JPL Science Data Evaluation Board (SDEB) approval to act as the reviewing board for this task; and developing policies and procedures for disposition, performing initial data set identification and storage assessment, and producing a high-level identification/assessment database. FY-93 activities will include: interacting with the SDEB, PDS Council Members and PSDSG on data set preservation priorities; continuing discussions with the National Space Science Data Center (NSSDC), SDDRT, PDS, and NASA personnel in identifying dataset redundancy and uniqueness; obtaining SDEB/PDS review/approval on final data disposition policies and procedures; performing detailed evaluation of datasets by contacting knowledgeable personnel about dataset details; sizing the handling and conversion requirements for those products deemed valuable for long-term retention; and reporting on task status monthly. Future activities include implementing adequate handling and storage techniques; investigating data conversion options for those products deemed by PDS Council/SDEB to be valuable for long-term preservation; and establishing conversion schedules in conjunction with PDS/PSDSG.

**W93-70487****656-61-21**

Goddard Space Flight Center, Greenbelt, MD.

**DATA MANAGEMENT INITIATIVE - NATIONAL SPACE SCIENCE DATA CENTER**

R. E. McGuire 301-286-7794

An increasingly urgent issue in the management of the scientific data collected from past NASA missions is the need to migrate critical data to new media and take other actions in documenting or formatting data to assure its preservation and optimal future usability. This multi-year RTOP will enhance the efforts already underway at the National Space Science Data Center (NSSDC) to identify, prioritize, migrate to new media, document and otherwise more effectively manage and make accessible the most important data in the current NSSDC archive. Elements of planned work include (1) interactions with Office of Space Science and Applications (OSSA) discipline offices and the designated representatives of their science communities to define the importance of various NSSDC data holdings for archival retention and restoration targets; (2) direct migration of important data from older media to new media, with backups and appropriate plans and procedures defined to assure the subsequent retention of such data; (3) improvements in documentation, validation, formats, near-line/on-line access, and data publication (e.g., via CD-ROM) and/or more specialized recovery efforts to improve usability of critical data; and (4) safe archival storage data in fully National Archives and Records Administration/National Institute of Standards and Technology (NARA NIST) and industry standards compliant facilities.

**W93-70488****656-65-04**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**IMAGE ANIMATION LABORATORY FOR SCIENCE VISUALIZATION**

D. F. Stanfill 818-354-3742

(656-65-06; 186-00-00; 656-74-03)

This task will develop visualization technology to allow integration of scientific data from several disciplines for the analysis of multi-dimensional images, including animations at the highest useful spatial resolution. This development will assist scientists in their research; Earth Scientists, Planetologists, and Astrophysicists use several dimensions to address many of their problems, yet most data are represented and analyzed in 2 dimensions. Interactive tools will be developed in a workstation environment to properly combine and then visualize multidisciplinary data in several dimensions. These tools include visualization and analysis of very high resolution terrain data (elevation and/or imagery) mapped onto planar or quadric surfaces, volumetric data, and other multidimensional data. In addition, the tools include two and three dimensional animation, metadata visualization, and morphometric feature extraction. Attention will be given to the generalization of techniques so that similar three dimensional models may be constructed from comparable data sets. This work will be done in close cooperation with scientists whose data is being visualized. The approach of this RTOP is to use a task team - consisting of the scientists whose data is to be visualized and programmers - to further visualization capabilities in a manner consistent with achievable technology and scientific utility; and design and implement the software for portability and extensibility (i.e., generic X-windows implementations) using commercially available general purpose computing platforms (Sun SPARC, Silicon Graphics IRIS). This includes a 'scientist friendly' user interface. Additional data types will be incorporated by extending existing techniques and developing new techniques. The methods, techniques, and tools developed in previous FY's will be generalized to handle a broader range of scientific data and will be delivered to scientists for feedback.

**W93-70489****656-65-05**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GRAPHICAL METHODS FOR SCIENCE VISUALIZATION AND DATA ANALYSIS**

A. S. Jacobson 818-354-0693

The long-term objective is to apply computer graphics methods and technologies to the interactive display, manipulation and analysis of large data sets. The specific objectives of the program are (1) to develop a software environment which will support the rapid prototyping of visual data analysis applications, while at the same time maintaining the high level of performance necessary



for interactively manipulating graphical displays; (2) to develop a user interface that is truly intuitive and easy to learn and allows quick access to the software for the novice as well as the advanced user; (3) to provide a suite of sample applications which are useful across a variety of scientific disciplines; and (4) to provide tools to support user development of applications for this environment. This is accomplished by a process of prototyping and using applications in close collaboration with scientific teams, engaged in research and data analysis in a variety of disciplines. The Linked Windows Interactive Data System, or LinkWinds, is the current prototype product of this research. It is a visual data analysis/exploration system designed to rapidly and interactively investigate large multivariate and/or multidisciplinary data sets to detect trends, correlations and anomalies. It is currently being used at several sites both within JPL and at outside institutions.

**W93-70490****656-65-06**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SOLAR SYSTEM VISUALIZATION (SSV): SCIENTIFIC TOOLS FOR NASA/JPL IMAGE ARCHIVES**

E. M. DeJong 818-354-0302

(656-65-04; 656-61-07; 656-74-03; 196-41-71)

The first objective is to create a realtime, interactive, scientific visualization environment which allows scientists to personally control all aspects of visualization, analysis, and data assimilation processes. The goal is realtime interactive visual comparison of data with scientific models. The second is to develop a prototype high performance science analysis workstation and an inexpensive previewing image animation workstation, and to adapt existing tools and develop new scientific tools for use with the NASA/JPL solar system exploration archive. The workstations will be testbeds for evaluating and comparing new computer algorithms and architectures. The third is to create planetary science Image Data Sets (IDS), and scientific visualization and analysis problems. The image data sets and problems would serve as benchmarks. They would be used to compare and evaluate new visualization and analysis algorithms/systems, and as educational material. They will be stored on CD-ROM for inexpensive distribution. The fourth is to integrate and test these tools and to provide a quantitative assessment of the achievement of the first three objectives. Scientific tools, image data sets and benchmark programs will be developed to meet the needs of the planetary science community, as reflected by current flight projects. The Earth, from a global/planetary perspective, will also be included. The SSV science team will test the effectiveness of the visualization, scientific analysis, and data assimilation tools. Collaborations will be developed with flight projects, including: Mars Observer, Mars Environmental Survey, Magellan, Galileo, and Ulysses.

**W93-70491****656-65-07**

Goddard Space Flight Center, Greenbelt, MD.

**CENTER OF EXCELLENCE FOR SPACE DATA INFORMATION SCIENCES (CESDIS)**

J. M. Hollis 301-286-7591

The objective is to operate at GSFC a Center of Excellence for Space Data and Information Sciences (CESDIS) which will consist of a consortium of university, industry, and government scientists engaged in computer science research addressing NASA's long-term space and Earth sciences data and computational problems. This RTOP will support a contract with the Universities Space Research Association (USRA) to administer, coordinate, and manage the award of grants to participating universities: to negotiate appointments of industrial and government associates to CESDIS; to conduct periodic peer reviews of CESDIS by the USRA Council; and to act as the interface between NASA and CESDIS.

**W93-70492****656-65-21**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**DATAHUB - KNOWLEDGE-BASED ASSISTANCE FOR SCIENCE VISUALIZATION AND ANALYSIS USING LARGE DISTRIBUTED DATABASES**

T. Handley 818-354-7009

(656-65-05)

This RTOP addresses four areas of significant need: scientific visualization and analysis; science data management; interactions in a distributed, heterogeneous environment; and knowledge-based assistance for these functions. The fundamental innovation embedded within this RTOP is the integration of three automation technologies, via knowledge-based expert systems, science visualization, and science data management. This integration is based on a concept called the DataHub. With the DataHub, NASA will be able to apply a more complete solution to all nodes of a distributed system. Both computational nodes and interactive nodes will be able to effectively and efficiently use the data services (access, retrieval, update, etc.) in a distributed, interdisciplinary information system in a uniform and standard way. This will allow the science investigators to concentrate on their scientific endeavors, rather than to involve themselves in the intricate technical details of the systems and tools required to accomplish their work. Thus, science investigators need not be programmers. The emphasis will be on the definition and prototyping of system elements with sufficient detail to enable data analysis and interpretation leading to publishable scientific results. In addition, the proposed work includes all the required end-to-end components and interfaces to demonstrate the complete concept. The DataHub will also be coupled as a data provider with the science data analysis tools/environments LinkWinds.

**W93-70493****656-65-22**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**GEOGRAPHICAL INFORMATION SYSTEM FOR FUSION AND ANALYSIS OF HIGH-RESOLUTION REMOTE SENSING AND GROUND TRUTH DATA**

A. Freeman 818-354-1887

We seek to combine high-resolution remote sensing data with ground truth measurements and radar image models in the context of a Geographical Information System (GIS). The GIS database will be integrated with an existing set of image/data analysis tools and visualization techniques. Then via case studies of two forest sites, one boreal and one tropical, we will investigate the correlation between ground truth, e.g., biomass and vegetation water content, and the remotely sensed data to study various aspects of forest ecology, e.g., change with temperature, different species, and the effects of rainfall. The data set and software tools will also be used to validate the radar models, which are based on ground data measurements. We will make use of a unique set of calibrated synthetic aperture radar (SAR) data at two forest sites, together with ground data maps and data from optical/infrared (IR) sensors. This data will be incorporated into a JPL-developed GIS database, termed Video Image Communication and Retrieval (VICAR)/Image Based Information System (IBIS). We will use the software at our disposal to geocode the radar data, classify, analyze and visualize it, correlate it with data from other sources, and model the radar backscatter response to changes in key biogeophysical parameters. Existing image processing software will be integrated into the GIS in a 'toolkit' format, which can be easily extended for additional applications.

**W93-70494****656-65-24**

Ames Research Center, Moffett Field, CA.

**CONSTRUCTION OF AN ADVANCED SOFTWARE TOOL FOR PLANETARY ATMOSPHERIC MODELING**

H. Lum 415-604-6544

(595-12-22)

The construction of scientific software models is an integral part of doing science, both within NASA and within the scientific community at large. Typically, model-building is a time-intensive and painstaking process involving the development of very large, complex computer programs. Despite the considerable expenditure

of resources involved, completed scientific models cannot easily be distributed and shared with the larger scientific community due to the complex, idiosyncratic nature of the implemented code. To address this problem, this research proposes constructing a software tool called the 'Scientific Modeling Assistant' that serves as an aid to the scientist in developing, using, and sharing models. To facilitate model-building, we propose building a software system that incorporates an interactive intelligent graphical interface, a high-level domain-specific modeling language, a library of physics equations and experimental datasets, and a suite of data display facilities. Rather than construct models using a conventional programming language, scientists will use our graphical interface to 'program' visually using a more natural high-level data flow modeling language. In constructing this tool, we will use a variety of advanced software techniques, including artificial intelligence techniques, as well as techniques from object-oriented programming, graphical interfaces, and visualization. To test this approach, we will build a software prototype in the domain of planetary atmospheric modeling.

**W93-70495****656-65-25**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MULTI-CHANNEL HOLOGRAPHIC BIFURCATING NEURAL NETWORK SYSTEM FOR REAL-TIME ADAPTIVE EOS DATA ANALYSIS**

A. Walton 818-354-3469

The overall objective of this RTOP is to produce an optical adaptive resonant system (OARS). To achieve the objective, the work is divided into three phases. During the first phase, the underlying behavior of the OARS including the data throughput capacity, cross-correlation interference, fault tolerance, and signal-to-noise ratio properties are studied via theoretical analysis and experimental test. The objective of the Phase 2 work is to investigate hardware implementation for breadboard demonstration. The third phase objective is to see how the system can be used for Earth Observing System (EOS) data analysis and other applications. The approach to achieve the RTOP objective includes the state-of-the-art techniques of free-space holographic interconnection and optical parallel processing capabilities with multi-channel input capacity. The multi-channel input is realizable by holographic optical elements (HOE) and high speed updatable Spatial Light Modulators (SLM's). Photorefractive crystals will be used for the formation of the bifurcating decision-making process. The OARS has a 'brain-like' nature. In the implementation of an OARS, we store the a priori known objects in photorefractive crystals in holographic grating form with the unique features of artificial plasticity for self-programming capability. Then any new input can be compared at high speed with the stored images for recognition and classification.

**W93-70496****656-65-26**

Goddard Space Flight Center, Greenbelt, MD.

**A SPATIAL ANALYSIS AND MODELING SYSTEM FOR ENVIRONMENTAL MANAGEMENT**

F. L. Stetina 301-286-5717

This is a proposal to develop a uniform global environmental data gathering and distribution system to support the calibration and validation of remotely sensed data. The Spatial Analysis and Modeling System (SAMS) is based on an enhanced version of the Federal Emergency Management Administration's (FEMA's) Integrated Emergency Management Information System and the Department of Defense's (DoD's) Air Land Battlefield Environmental Software Systems. The approaches are as follows: (1) to complete the system integration and software development plan; (2) to work with the U.S. Corp of Engineers and FEMA to select the test site for flood plan forecast and hydrological applications model selection; (3) to complete evaluation of image processing software, Geographical Information System (GIS) software, and system integration software; and (4) to complete development of satellite precipitation maps over the test site area.

**W93-70497****656-65-27**

Goddard Space Flight Center, Greenbelt, MD.

**A DISTRIBUTED ANALYSIS AND VISUALIZATION SYSTEM FOR MODEL AND OBSERVATIONAL DATA**

S. E. Koch 301-286-7188

The objective of this RTOP is to develop an integrated and distributed analysis and display software system for visualizing the massive amounts of data generated from satellites, observational field programs, and from model simulations during or after their execution. Components of the system will include General Meteorological Package (GEMPAK) analysis, data handling, and graphics capabilities (developed by NASA) and prototype software for three-dimensional interactive display and animation built at National Center for Supercomputing Applications (NCSA). Overall process control will be handled through evolving scientific application and visualization builder tools on UNIX-based supercomputers and workstations.

**W93-70498****656-74-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**CONCURRENT PROCESSING TESTBED - SCIENCE ANALYSIS**

M. Lee 818-354-2228

(656-65-04; 656-65-05; 656-65-06; 656-61-05; 186-00-00)

The major objective of this task is the extension of concurrent processing of testbed technology to an integrated science analysis environment. In the context of the National High Performance Computing and Communications (HPCC) Program, this includes providing a 'transitional environment' between modest performance (100 MFLOP's), concurrent systems, and systems capable of giga-/tera-flop performance. The four major elements of this objective are the following: (1) development and demonstration of integrated science analysis and visualization tools; (2) development and demonstration of a data/information management system for a distributed/concurrent computing environment; (3) development of techniques and utilities for heterogeneous distributed computing resources to support computationally intensive science analysis activities; and (4) development and demonstration of portability concepts in high performance computing architectures, wide area networks, and large data storage facilities. The approach to meeting these RTOP objectives draws heavily on the experience gained over the past few years in development and implementation of the concurrent processing testbed, the Concurrent Image Processing Environment (CIPE), and the Planetary Analysis Tool (PLATO) set. In addition, the experience gained in applying this technology to real-time science information extraction during the Voyager Neptune Encounter, Hubble Saturn Storm Study, and Magellan Mission will continue to be applied to the development of analysis tools and algorithms which are capable of handling the volume and complexity of data represented by the Earth Observing System (EOS), Galileo, and future planetary exploration missions. Focus for development and demonstration of science analysis capabilities will be provided by specific problems in current missions such as Planetary Atmospheric and Surface Topology Studies in support of Galileo Earth 2 Encounter and Magellan Data Analysis tools. The research team will work closely with a selected set of NASA scientists in the articulation of needs, the evaluation of potential solutions, and the development and testing of specific products. The products will be distributed to the science investigator community as part of the evolution of the PLATO set.

**Mission Operations and Data Analysis****W93-70499****665-35-00**

Ames Research Center, Moffett Field, CA.

**ERS-1 SAR INVESTIGATIONS OF METHANE EMISSIONS FROM HIGH LATITUDE ECOSYSTEMS**

L. A. Morrissey 415-604-3617

The objective of this research is to assess the role of northern wetlands in the global methane budget. The approach utilizes aircraft (AIRSAR) and ERS-1 satellite radar data to seasonally monitor environmental parameters as they relate to methane emissions: wetland inundation levels (providing an anaerobic substrate for methanogenesis), vegetative leaf area (plant-mediated transport pathway for methane), and phenology (period of biological activity for methane bacteria). Physically-based radar modeling of multifrequency, multipolarized AIRSAR will be conducted to understand the physics of radar interaction with wetland vegetative and hydrologic parameters. These radar-derived data layers will be integrated into a geographic information system to improve current seasonal and regional estimates of methane emissions.

**W93-70500****665-35-01**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ASF SAR INTERFEROMETRY**

H. A. Zebker 818-354-8780

We propose to apply interferometric radar topographic techniques to the study of active Alaskan volcanoes, motion and stress of glaciers, and permafrost cycle heaving of the surface. Since radar interferometry permits mapping of surface heights, changes in surface heights, and surface lateral displacements, it is an appropriate tool for the study of these phenomena. The ERS-1 radar and Alaska Synthetic Aperture Radar Facility (ASF) will provide data from which we may derive topographic maps of 10 m height accuracy over images tens of kilometers in extent at a spatial resolution of 20 to 30 m. It may also be possible to generate topographic change maps, on a relative rather than absolute scale, sensitive to cm scale changes in height that may serve as precursors to eruptive events. These changes in height may also be used to monitor the ground heaving associated with the thawing of soil layers in the Arctic regions. We plan to monitor the thickness above the permafrost layer as the ice melts, thereby, causing the absolute height of the ground to drop as the water drains from the layer. Finally, displacements of the surface as small as a fraction of a 6 cm wavelength are observable in the interferometer images. This property allows us to track glaciers even as they move at very slow rates. Since we measure many 20 m resolution elements on a typical glacier, any differential motion which can lead to stresses in the ice may be monitored. Our approach is to utilize ERS-1 data acquired during the commissioning phase and during the ice three day repeat orbit in order to achieve maximum correlation between the radar signals. These data will be processed to complex images, and interferograms between pairs of data sets will be derived. These interferograms are easily reduced to topographic maps if altitudes at a few tie points are known; also any shifts in position (motion) may be ascertained. The interferogram pairs may then be combined to measure the topographic change in an area, which is needed for the permafrost investigation. Any systematic errors in height estimation are removed in this process, so that the resulting sensitivity to change is on the size scale of cm.

**W93-70501****665-35-09**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ESTIMATION OF GREENLAND SEA BRINE AND FRESHWATER FLUXES FROM ERS-1 AND SSM/I DATA**

F. D. Carsey 818-354-8163

The principal objective is the estimation of fluxes of brine and freshwater from sea ice formation and melt in the Greenland Sea with emphasis on brine production in the winters of 1989 and 1992. This flux densifies the mixed layer of the Greenland Sea and drives the deep convection that is the primary source of Atlantic Intermediate Water. This process is known to be active, in some but not all winters, in the region of the Greenland Gyre centered near 0 degrees E, 74 degrees N. Fresh water fluxes through Fram Strait are a significant aspect to air-sea interaction in the Greenland Sea. The estimates will be drawn from a combination of ERS-1 Synthetic Aperture Radar (SAR) data acquired at European stations, Special Sensor Microwave/Imager (SSM/I) microwave brightnesses, and environmental analyses. The approach will be to use: (1) ice motion and divergence fields

generated from SAR analysis to track the ice and to provide open-water production; and (2) SSM/I data, using algorithms which we are developing to monitor the development of the ice cover in time. The brightnesses in the SSM/I wavelengths have previously been shown to be sensitive to the growth of the ice from open water to about 30 cm thickness where the ice attains the radiance of thick first-year ice. Key issues to be addressed are the sensitivity and noise levels in the SSM/I brightnesses and the accuracy with which the ice motion data can generate estimates of opening and closing of the ice. This project is done in collaboration with U.S. and European investigators in the Greenland Sea Project; the in-situ oceanographic data collected by that project will serve as both auxiliary data and validation data. In sum, three methods will be used to estimate the brine flux: a SAR analysis, the SAR + SSM/I analysis, and a bulk flux formulation; an error-minimizing procedure, such as Kalman filtering, is ultimately envisioned to select the most likely flux quantity. Fresh water fluxes will be addressed through the estimation of ice areal flux through Fram Strait multiplied by the ice thickness data to be acquired by upward-looking sonar on a mooring.

**W93-70502****665-35-10**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ERS-1 SAR INVESTIGATION OF ICE KINEMATICS AND SURFACE WIND FIELDS IN THE WEDDELL SEA**

M. R. Drinkwater 818-354-8189

(461-62-10)

Investigation will be continued into coupling between surface winds and sea ice in the Weddell Sea, Antarctica on scales of 100 sq km. The objective is to order ERS-1 Synthetic Aperture Radar (SAR) image data, downlinked to the German Antarctic Receiving Station (GARS) on the Antarctic peninsula, throughout a period of ongoing intensive surface experiments during February to August 1992. Surface experiments will be conducted aboard the research vessel Polarstern between May and August to monitor wind stress and ice divergence in conjunction with Argos buoy deployments. Ice kinematics data, extracted automatically from SAR image pairs using the Geophysical Processing System (GPS) at the Alaska SAR Facility, will be combined with ice divergence data supplied from the Argos drifter arrays and then compared with the wind stress data. An investigation of the momentum balance and derived empirical relationships between wind stress and sea ice divergence will be used to simulate and hindcast the wind speed and direction from gridded ice motion fields. The objectives of this RTOP are: (1) to acquire and process ERS-1 SAR data already collected in the Western Weddell Sea, from the German processing and archiving facility. Further data requests will be placed for simultaneous coverage in the Eastern Weddell Sea during the Winter Weddell Sea Polarstern experiment in the time window from 27 June to 30 July; (2) to generate ice motion and other GPS products from the Western Weddell Sea SAR data collected in the three-day PIPOR orbit phase and combine these with Argos drifter deformation at approximately 50 km spacing around Ice Station Weddell, to establish the relative ice motion field around the ice camp; (3) to participate in the Winter Weddell Sea Gyre Study aboard RV Polarstern on experiment Ant X/4 between May 21 and August 5, 1992; and (4) to analyze buoy motions and satellite-tracked corner reflectors to validate three-day SAR motion products and to investigate the integrity of short-term ice motion field. The approach is (1) to generate images and geophysical products from Weddell Sea ERS-1 images using the Alaska SAR Facility (ASF) Geophysical Processing System; (2) to display and create gridded ice motion fields using available three-day repeat image pairs from the ice orbit and from the 35-day repeat orbit, multi-disciplinary phase of the ERS-1 mission; (3) to conduct buoy and corner-reflector array deployments and participate in acquisition of supporting meteorological, microwave, and surface characterization measurements from the Polarstern vessel during the AnZone experiment; and (4) to evaluate ice motion fields in the Western and Eastern Weddell Sea and to test existing empirical relationships derived from the ice momentum balance which relate air-ice stresses with ice divergence, drift speed, and turning angle.

**W93-70503****665-82-03**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**WINDOWS ON GLOBAL CHANGE**

R. A. Kahn 818-354-9024

The primary objective of this project is to address the question of how NASA Earth science data relating to Global Change will be made useful to middle school students for educational purposes. Students must learn: (1) the elements of the scientific method, as applied to working with real data; (2) the operation of software such as spreadsheets, image processing, and word processing tools; and (3) some facts and approaches to the study of global change issues, such as multispectral classification of images, picture differencing, calculation of regional and zonal mean quantities, using time-series (stratigraphic) information, comparative planetology, and budget calculations. Our approach is to produce a workstation environment that includes as utilities the necessary tools, together with databases of relevant digital image, video, and tabular material, and a structured set of interactive explanations and examples we refer to as the 'tell' and 'ask' modes of operation. Project development is organized around a science team, which is responsible for content and validity of the material, an education team, which leads the classroom model development and field testing activities, and works with the science team to set the level of explanation, and a technical design team. This RTOP supports the project scientist, who has also had primary responsibility for developing the workstation concept described here, and is science team leader. The content of the tell and ask modes is divided into a 'Pilot' Project and the Full Project. The Pilot Project is intended to test innovations in content, educational style, and technical design. It focuses on basic classification and interpretation of digital images, simple statistical summarization of globally distributed data, basic graphing skills, geological reasoning, seasonal and glacial-period changes in the Michigan area, and comparisons with seasonal and long-term changes in a similar-sized region around the South Polar Cap of Mars. The Full Project will include many more topics, such as basic radiative transfer and greenhouse warming, simple photochemistry and the ozone hole, plate tectonics and secular climate change, etc., and will include a communications utility allowing students to import and work with data from remote databases, such as the Global Encyclopedias currently under development by NASA and other agencies.

## Search and Rescue Mission

**W93-70504****669-30-10**

Goddard Space Flight Center, Greenbelt, MD.

**ADVANCED SEARCH AND RESCUE TECHNIQUES**

W. A. Hembree 301-286-8332

In accordance with the NASA commitment to the National Search and Rescue Plan, application of aerospace technology to supporting the search and rescue community will continue. Specifically, we will: (1) enhance the future effectiveness and scope of the SARSAT system; (2) develop and demonstrate airborne and space-based systems using remote sensing technology to assist search and rescue without the aid of emergency beacons; (3) develop near-instantaneous distress alerting using geosynchronous satellites; and (4) develop means for applying remote sensing and satellite communications technology in aiding disaster mitigation and recovery. The approach will be to: (1) develop improved SARSAT receiver-processor design with decreased susceptibility to interference; (2) develop and demonstrate prototype low-cost satellite-compatible beacons; (3) procure a synthetic aperture radar system and with it perform additional experiments to establish the range of conditions under which it is effective in detecting crashed aircraft under a forest canopy; (4) refine techniques for isolation of aircraft targets in radar imagery and perform user demonstrations; (5) characterize

performance of GOES search and rescue ground station; and (6) support NASA efforts in demonstration of disaster mitigation techniques and systems.

## Space Processing Science and Spacelab Payload Development

**W93-70505****674-21-05**

Lewis Research Center, Cleveland, OH.

**ELECTRONIC MATERIALS**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The plan for this task is to continue an in-house cooperative project with Westinghouse Research Laboratories and to manage a contract with Westinghouse to study the growth kinetics of physical vapor transport processes. The objectives of this project include achieving a quantitative understanding of crystal growth processes, identifying convective effects, and obtaining optimal process control parameters for desired crystal structure and properties. We concentrate on physical vapor deposition and Bridgman growth and typically use high temperature transparent furnaces to allow observations of growth of technologically significant materials.

**W93-70506****674-21-08**

Marshall Space Flight Center, Huntsville, AL.

**ELECTRONIC MATERIALS**

Sandor L. Lehoczky 205-544-7758

In any crystal growth system, an important problem is that the compositional and/or thermal fluctuations in the fluid phases cause compositional inhomogeneities and defects in the growing crystal. Where these fluctuations are caused by convection and sedimentation, they can be reduced in low gravity. Therefore, the major objectives of this crystal growth program are as follows: (1) to understand the role of gravity and determine limitations in Earth's gravity; (2) to determine and demonstrate advantages to be obtained by growing crystals in space; and (3) to apply the findings to help solve problems in the growth of electronic and detector crystalline materials. The types of growth that will be explored in this program include melt, solution, vapor, and float zone growths. Crystal growth by solidification from the melt is the most widely used technique for high technology single crystalline materials. The success of the technique depends on the control of the composition, temperature, and morphology of the solidification interface. Advantages of the solution growth technique include the control it provides over the temperature of growth and viscosity. In the vapor approach, there are two distinct mechanisms for growing a crystal: (1) the physical vapor deposition; and (2) the chemical vapor deposition (CVD). Finally, floating zone crystal growth is accomplished by supporting a polycrystalline rod at both ends, melting a portion of it with a moving heater, and growing a crystal behind this zone.

**W93-70507****674-22-05**

Lewis Research Center, Cleveland, OH.

**COMBUSTION SCIENCE**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of the activities covered by this RTOP is to obtain an understanding of the fundamental combustion phenomena for which low-gravity analysis and experimentation can be of use in the following: (1) isolating the gravity-related mechanisms (e.g., buoyant convection); (2) determining the influence of transport phenomena normally obscured by gravitational effects (e.g., thermophoresis, thermocapillarity, simple mass, and thermal diffusion); (3) creating desired symmetries

and/or boundary and initial conditions (e.g., spherical droplets, negligible sedimentation); and (4) improving in-space system performance, principally spacecraft fire safety. After justifying the need for microgravity research, Principal Investigators from academia, industry, NASA, and other governmental agencies are chosen to develop analytical and theoretical models and supporting experiments--whenever possible--in ground-based laboratories. Experimental and theoretical results are then evaluated to determine if together they provide a satisfactory understanding of the combustion phenomena under study. It should be noted that in many cases, the low-gravity experiments reveal new and unexpected phenomena, so that rather than guiding the experiments, theoretical investigations may be instigated after experimental completion. When the test-time or gravity-level limitations of ground-based laboratories preclude conclusive experiments, the Principal Investigator defines additional experiments to be conducted in space-based laboratories. The Principal Investigator then performs supplemental analyses and experiments to develop the conceptual design of space-based hardware and select the desired test conditions for the eventual experiments. These studies are presented in a Science Requirements Document and a recommended conceptual design for the hardware which together summarize the justification and feasibility of the experiment. Participation by investigations in this RTOP is based primarily on competitive selection through NASA Research Announcements (NRA's); in FY-93, 14 of the 16 investigators supported by this RTOP received approval following their response to NRA-89-OSSA-22, Microgravity Combustion Science.

**W93-70508****674-23-01**

Lyndon B. Johnson Space Center, Houston, TX.

**BIOTECHNOLOGY RESEARCH**

G. F. Spaulding 713-483-2357

This research is focused on the development of science in support of the NASA Biotechnology Program. The projects within the RTOP will have five general objectives: (1) to gain a better applications understanding of basic cell science questions of importance to current biotechnology which have apparent gravity induced limitations or can be better studied in the microgravity environment; (2) to study unique bioprocess limitations caused by gravity dependent phenomena and determine the potential for improvement during biological processing in microgravity; (3) to develop methodology and procedures for accomplishing biotechnology investigations in microgravity; (4) to explore new research applications of biological target materials and new technology innovations; and (5) to define and develop analytical methods and requirements for biotechnology research facilities planned for the U.S. Space Station. This RTOP is designed to serve as a basic science resource in support of NASA Biotechnology. Research will be performed both in-house at Johnson Space Center (JSC) and at associated universities, research centers, and institutions. JSC will perform independent research and serve as a point of contact for the extramural investigators. JSC will participate in the analysis of results, promote scientific communication, and aid the investigators in the development of NASA relevant research efforts. Scientific data resulting from these studies will be used to formulate new proposals for flight experiments, promote ground-based applications of these technologies, and refine the scientific background and justifications for proposed flight experiments.

**W93-70509****674-23-08**

Marshall Space Flight Center, Huntsville, AL.

**BIOTECHNOLOGY**

Robert S. Snyder 205-544-7755

The long-range objective is to utilize the environment of space to separate, purify or crystallize, and analyze biological products. The intermediate objectives are to develop the required technology and to expand the base of knowledge involved with processing biologicals in space; to identify, evaluate, and select the most promising processes; and to explore new areas of separation technology. Separation and purification procedures which have

been found to produce inadequate results on the ground because of gravity-dependent problems will be investigated. More specifically, this program will determine possible advantages of the low-gravity environment for separation, purification, crystallization, and characterization of biomedical materials; design, develop, manufacture, and test experiment apparatus to conduct experiments in low gravity; apply ground/flight knowledge to the improvement of bioprocessing procedures on Earth; develop broad and strong collaborative interactions with research scientists; and identify and explore new techniques of separation or bioprocessing that might be enhanced by low gravity.

**W93-70510****674-24-00**

Langley Research Center, Hampton, VA.

**FLUID PHYSICS**

J. F. Creedon 804-864-6033

The objective of this research area is the ground based development of theory and techniques which will support microgravity science flight experiments. The approach is the development of mathematical models, fluid flow measurement techniques, and basic scientific knowledge which are applicable to microgravity science experiments.

**W93-70511****674-24-05**

Lewis Research Center, Cleveland, OH.

**FLUID PHYSICS**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of the activities covered by this RTOP are to expand our understanding of fundamental fluid physics/fluids transport phenomena and the effects of gravity on those phenomena through studies which exploit the unique conditions that prevail in a reduced gravity environment. The pursuit of this understanding is directed to a wide range of scientific endeavors of interest to the general fluids community as well as specific applications such as supporting the design and development of advanced technologies/techniques for space-based materials processing and fluid management systems. Because of the wide range of applications and the large disparity of fluid processes/conditions encountered in these applications, the strategy used to address as many significant fluids issues as possible is to concentrate on a much smaller set of reasonably self-contained research topics or areas of fundamental understanding. At LeRC the topics/areas of interest include the following: (1) Phase Transitions (first order and second order); (2) Multicomponent/Coupled Transport Flow; (3) Magneto-Electro-Hydrodynamics; (4) Multiphase Flow; and (5) Capillary Phenomena. In general, idealized simple systems using reference fluids mean ambient temperatures are chosen for initial modeling and experimental work before proceeding to studies of more application specific configurations and conditions. Principal Investigators from academic institutions, industry, other Government agencies and NASA LeRC are currently involved in a variety of research focused on providing a foundation of fundamental understanding of low-gravity fluid behavior/phenomena. Emphasis in the early stages of the research programs is on analytical/numerical modeling and normal gravity laboratory tests to provide predictive capabilities. When possible, these efforts are followed by low-gravity testing in ground-based facilities to provide more specific data for further model refinement; while the relatively short low-gravity test time limits the data that can be obtained, in many cases a significant amount of valuable information can be acquired. This is particularly true when scaling analyses can be applied with confidence. When the capabilities of the ground-based low-gravity facilities are exhausted or found to be inappropriate, efforts then are directed toward the development of science requirements and conceptual designs for space flight experiments.

**W93-70512****674-24-08**

Marshall Space Flight Center, Huntsville, AL.

**FLUID PHYSICS**

Robert S. Snyder 205-544-7755

The objective of this RTOP is to develop experimental and theoretical methods for the study of the effects of gravity on the behavior of fluids undergoing phase transformations. Of particular interest are the quantitative effects of boundary conditions on the nature of the heat and mass transfer processes that accompany the solidification of materials. Experimental and theoretical work will be carried out to understand the electrokinetic properties of particulate suspensions and check the fundamental concepts of the physics of the equivalence principle. Other objectives are to develop a body of data on the conductivity and dielectric behavior of various particulate suspensions and develop a theory to describe how the dielectric constant and conductivity depend on the properties of the suspension, and to test the Einstein Equivalence Principle to a very high accuracy to check fundamental concepts of physics.

**W93-70513****674-25-05**

Lewis Research Center, Cleveland, OH.

**METALS AND ALLOYS**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of the Metals and Alloys RTOP is to conduct fundamental research on transport behavior of liquid metals to better understand such phenomena as nucleation, pattern selection during solidification, phase separation, diffusion, coarsening, and segregation. Extensive use is made of model materials such as lead-tin alloys and transparent organic analog systems. The ultimate goal is to use this understanding to improve current or develop new theories, models, and ground-based materials and processes. The experience gained also contributes to preparation of materials processing in space, e.g., welding or space mineral processing. Near term targets include definition of parameters for space-based cellular and dendritic solidification experiments, critical re-examination of published work to determine reasons for discrepancies between existing models and theories for dendritic and cellular growth, development of quantitative techniques for observing transparent crystal growth, evaluation of the potential of bulk undercooling as a microgravity process, and examination of the zone melting technique for application to advanced metallic materials.

**W93-70514****674-25-08**

Marshall Space Flight Center, Huntsville, AL.

**METALS AND ALLOYS**

Peter Curreri 205-544-7783

Control of the solidification of metals and alloys is keyed to gravitational effects such as buoyancy-driven convection. Thus, the objectives of the study are to: identify various aspects of solidification phenomena that may be affected by gravity-driven flows; devise and conduct critical experiments in both increased gravity as well as in space; and impact the field of metallurgy by fundamental knowledge through devising better control strategies. Multicomponent metallic systems involve a first-to-freeze component which nucleates and begins to grow, causing the composition ahead of the solidification front to change dramatically. Where it is infeasible or undesirable to provide controlled gradients for a planar solidification front, dendritic growth results. Thus, concentration is one of the more fundamental problems involved in the formation of dendrites. Directional solidification affords a degree of control because unidirectional thermal gradient can be imposed and growth rate regulated. Another important class is the monotectic alloys which have a region of immiscibility. Finally, nucleation and rapid solidification of deeply undercooled melts will be pursued by containerless melting and solidification.

**W93-70515****674-26-05**

Lewis Research Center, Cleveland, OH.

**GLASSES AND CERAMICS**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of this RTOP is to identify and initiate fundamental research in the areas of glasses and ceramics wherein microgravity related phenomena play an important role. Phase

immiscibility in glasses has been initiated as an in-house research effort and an AO proposal was submitted. Research involving order-disorder transitions of ceramic slips and agglomeration of ceramic powders has been sponsored. Though included in combustion science, there is some new work at the University of Colorado on self propagating thermal reactions for the preparation of continuous ceramic networks, metal filled composites. Ceramic powder agglomeration research has been tied in with laser light scattering development in the MMSL. A new effort in fiber growth has been initiated via an NRC fellow.

**W93-70516****674-26-08**

Marshall Space Flight Center, Huntsville, AL.

**GLASSES AND CERAMICS**

Edwin C. Ethridge 205-544-7767

The objectives of this activity are to perform studies that utilize the unique capabilities of space processing to investigate particular problems in the science and engineering of glasses and ceramics. These include the study of gravity dependent behavior in melts; the investigation of container induced heterogeneous nucleation effects; the examination of novel techniques and applications for containerless processing of glasses and ceramics; development of pseudo containerless processing methods for use with glass and ceramics; and understanding and defining the limitations of processing in 1-g to support the development of meaningful flight experiments. The experiments can be grouped into two categories, fluids experiments and containerless processing experiments. Fluids experiments include the investigation of phenomena such as bubble motion, containerless viscosity and surface tension measurements, and inviscid fluid fiber pulling experiments. The fluids class of experiments require low-g in order to minimize convection or hydrostatic flow. Containerless processing is the other important class of the glass and ceramic experiments. The difficulty in levitating and melting glasses and ceramics in 1-g has had a limiting effect on the development of the discipline.

**W93-70517****674-27-05**

Lewis Research Center, Cleveland, OH.

**MICROGRAVITY MATERIALS SCIENCE LABORATORY (MMSL)**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of the MMSL RTOP is to maintain and operate a dedicated, well equipped laboratory for the performance of ground-based studies in support of the Microgravity Science and Applications Division flight program. This laboratory is open to scientists from academia, industry, and government. It contains equipment and facilities for simulation and emulation of some aspects of the microgravity environment as well as apparatus chosen to imitate flight apparatus. It contains a numerical analysis facility, the Computational Materials Laboratory, which addresses fluid flows in microgravity. It models microgravity experiments, apparatus, and equipment. It is staffed by a small group of engineers and technicians providing a varied background in materials, chemistry, computer science, mechanical engineering, and physics. Funding is required for support of the support service contractor technicians working in the lab, for purchase and maintenance of facilities, for supplies, and for operation of a metallographic laboratory.

**W93-70518****674-28-05**

Lewis Research Center, Cleveland, OH.

**GROUND EXPERIMENT OPERATIONS**

Nancy J. Shaw 216-433-3285

(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of the activities funded under this RTOP is to provide the human resources, equipment, and facility support necessary to perform reduced gravity experiments in the LeRC 2.2 Second Drop Tower, Zero-Gravity Facility, Learjet, and supporting laboratories. Experiments are conducted to support both principal investigator studies and LeRC in-house studies primarily in fluids and combustion science. Funding is utilized for aircraft



flight hour charges, composite rate charges for aircraft operations engineering support via a support service contract, engineering design through a university (Case Western Reserve) cooperative agreement, a variety of facility support hardware, components, and instrumentation, and composite rate charges for technician support.

**W93-70519****674-28-08**

Marshall Space Flight Center, Huntsville, AL.

**GROUND EXPERIMENT OPERATIONS**

Michael B. Robinson 205-544-7774

This RTOP covers work in the area of defining, developing, and conducting experiments using the low-gravity capabilities of the drop tube. Such experiments may be in themselves complete investigations to develop new knowledge or to prove theories, or they may serve as precursors for more extensive experiments to be conducted in space. This RTOP also includes studies and experiments to define the effects of various levels and durations of acceleration perturbations on microgravity experiments.

**W93-70520****674-29-08**

Marshall Space Flight Center, Huntsville, AL.

**CONSULTING AND PROGRAM SUPPORT**

Robert S. Snyder 205-544-7755

The objectives of this RTOP are to provide the necessary scientific manpower to augment the implementation of the Microgravity Science and Applications (MSA) research and technology development effort, and to provide the MSA program with an effective means of interacting with the various scientific communities involved for the purposes of: making them aware of the research opportunities offered by the MSA program; stimulating their interest and active involvement in the program; gauging their response to the scientific results being obtained by the program; identifying research areas in which the program should concentrate; initiating in-house research activities in selected topics pertinent to the MSA program; and evaluating the ongoing research effort. The Marshall Space Flight Center (MSFC) will ensure the necessary professional and supporting manpower to implement the MSA research and technology development effort. Also, the stated objectives will be met by actively involving the various research communities in the MSA program through the visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented with this documentation included in the NASA Headquarters data base for access to the scientific community, NASA Headquarters MSAD, and other NASA centers.

## Sounding Rockets

**W93-70521****879-10-00**

Goddard Space Flight Center, Greenbelt, MD.

**SPARTAN 201 WHITE LIGHT CORONAGRAPH**

R. R. Fisher 301-286-5682

The SPARTAN 201 White Light Coronagraph is an externally occulted doublet objective system used to make out or eclipse measurements of the brightness distribution of the solar corona. The field of view extends from 2.0 to 6.0 solar radii, as measured from the center of the sun's disk. This system, which uses a charge coupled device for image formation, will be used to infer the distribution of electron density near the sun during the operation of its companion instrument, the Ultraviolet Coronal Spectrometer, a second instrument provided by the Smithsonian Astrophysical Observatory. Together these instruments will be operated from the same spacecraft to gather a complete set of diagnostic observations from which limits may be set on the coronal electron density distribution, the proton density distribution, the electron and proton temperature distributions, and the flow velocities associated with defining the nature of the solar plasma in the

region of the solar atmosphere where it is believed the acceleration of the solar wind occurs.

**W93-70522****879-11-38**

Goddard Space Flight Center, Greenbelt, MD.

**SOUNDING ROCKET EXPERIMENTS**

Roger Thomas 301-286-3756

The objectives of this RTOP are as follows: (1) to develop solar extreme ultraviolet (EUV) and soft x ray sounding rocket payloads for the purpose of characterizing the physical processes of energy transport and dissipation in the transition region and corona and their relationships to heating of the corona, acceleration of the solar wind, and energy release and dissipation during solar flares; (2) to calibrate, launch, and analyze data from sounding rocket payloads developed under this RTOP; and (3) to correlate flight results with ground-based observations and theoretical models. The approach is to develop instrumentation that can both characterize the spatial morphology of the coronal emission and determine its thermal and non-thermal velocity components via measurements of EUV emission line profiles over a wide range of transition region and coronal electron temperatures. Activities include definition, design, calibration, and flight of rocket-borne instrumentation, analysis of resulting data and correlation with co-temporal observations, comparison of results with predictions based on models of coronal heating, solar wind acceleration, and solar flares.

**W93-70523****879-11-48**

Goddard Space Flight Center, Greenbelt, MD.

**PROPOSAL FOR A HIGH-ENERGY IMAGING DEVICE (HEIDI) ON A BALLOON**

C. J. Crannell 301-286-5007

The High Energy Imaging Device, HEIDI, is in the hardware development phase of its program for observations of solar flares during the current solar maximum. The primary scientific objective to be pursued with HEIDI is to image solar flares in hard x rays and gamma rays. HEIDI is based on the technique of Fourier transform imaging and utilizes modulation grid collimator optics that ultimately will provide full-Sun imaging with 2-arcsecond resolution over the energy range from 20 to 700 keV at time resolutions from 0.1 to 2 s. For the first flight scheduled for September 1992, HEIDI will employ two rotating modulation collimators (RMCs), each composed of a matched pair of high-Z collimator grids separated by 5.2 m. The two subcollimators provide slit spacings corresponding to angular dimensions of 11 and 25 arcseconds FWHM which correspond to a 5 to 40 arcsecond range of measurable scale sizes. A 9 cm diameter x 1.5 cm thick NaI(Tl) scintillation spectrometer will serve as the detector behind each RMC. The RMC's are mounted within a telescope canister that will be pointed to an accuracy of 0.1 degree. A canister mounted aspect system provides absolute fine pointing knowledge to 0.2 arcsecond every 20 ms. An adaptation of the LASER beam steering technique will enable off-SUN pointing with the solar aspect system for calibration of the hard x ray imaging system with non-solar sources. The instrument has an effective area of 30 sq cm and is designed for a one-day duration balloon flight at an altitude of 40 km or higher. The payload may be readily upgraded to 4 RMC's with an effective area of 130 sq cm.

## Mission Operations and Data Analysis

**W93-70524****889-59-00**

Goddard Space Flight Center, Greenbelt, MD.

**NEPTUNE DATA ANALYSIS**

B. J. Conrath 301-286-6088

This RTOP supports advanced analysis and interpretation of data acquired by the Voyager 2 spacecraft during the Neptune



encounter. Task 1 consists of an investigation of the thermal structure, dynamics, and cloud properties of Neptune's atmosphere. Data from the Voyager infrared spectroscopy experiment (IRIS) are used along with other Voyager and ground-based data. Task 2 is a study of the hydrocarbons in Neptune's atmosphere. The primary data source to be used is that from Voyager IRIS. Task 3 consists of analyses of the Voyager 2 Plasma Science Experiment (PLS) electron observations in the vicinity of Neptune. Task 4 is a study of the plasma properties and dynamics of the magnetopause/cusp regions and compares Neptune phenomena with their terrestrial counterparts.

**W93-70525****889-59-00**

Ames Research Center, Moffett Field, CA.

**NEPTUNE DATA ANALYSIS**

J. Cuzzi 415-604-6343

The major objectives of this RTOP are: (1) to search for lightning in the atmosphere, determine its latitude-longitude distribution, and determine the energy dissipation rate of lightning activity; (2) to determine the scattering properties of Neptune's and Triton's atmospheres; and (3) to constrain the structure and particle properties of the Neptunian ringmoon system. The approach is to analyze the images obtained by the Voyager 2 spacecraft specifically for these purposes and to conduct a parameter study with a theoretical model to determine the parameters needed to specify the scattering properties of the atmosphere.

**W93-70526****889-59-00**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**NEPTUNE DATA ANALYSIS PROGRAM**

J. D. Goguen 818-354-3943

This group of 15 research tasks addresses a range of data analysis and interpretation problems based on Voyager 2 observations at Neptune. Specifically, the science objectives encompass the use of radiative transfer models to investigate the planet's atmospheric structure including the global energy balance, composition, temperature, and cloud properties, and the use of Voyager data sets to study Triton's wind fields, Neptune's rings, and to search for small satellites. Voyager PPS, IRIS, and imaging data and Earth-based observations are used to study surface characteristics of Triton including its thermal history, topographic relaxation, solid volatile transport, solid-state greenhouse processes, and spectral reflectance properties (geometric and Bond albedos, phase integrals, and photometric function versus wavelength). Data from radio occultation experiments were used to infer the helium-to-hydrogen abundance ratio in Neptune's atmosphere. Radio science investigations are also used to improve our knowledge of Neptune's gravitational field and ephemeris. The approach makes use of direct inversion algorithms to determine temperatures from the infrared data and sophisticated radiative transfer/aerosol models to examine the solar reflection spectra. The best available ground-based and other spacecraft data are used together with the Voyager measurements to take advantage of the unique spatial, angular, and wavelength coverage available from the Voyager data. Algorithms are developed for creating maps of normal reflectances from Triton imaging data. This RTOP also includes extensive work on data archiving, cataloging, and dissemination.

## OFFICE OF SPACE COMMUNICATIONS

### Advanced Systems

**W93-70527****310-10-23**

Goddard Space Flight Center, Greenbelt, MD.

**SOFTWARE ENGINEERING TECHNOLOGY**

Frank McGarry 301-286-6846

The objective of this RTOP is to identify, develop, evaluate, and refine software engineering technology to significantly and continuously improve the software development process in NASA. This is accomplished through the Software Engineering Laboratory (SEL), which measures and assesses software engineering technologies within the Flight Dynamics Division (FDD). The SEL measures all software produced by the FDD to support GSFC missions. Successful technologies are incorporated into the FDD software development process. The research process consists of the following steps: (1) characterize the FDD development environment through standard measurements; (2) identify a potentially beneficial technology; (3) identify any new measures needed to understand and assess the new technology; (4) apply the new technology to production projects; (5) compare measures for the new technology to the baseline characteristics; and (6) package successful technologies into development guidelines and training.

**W93-70528****310-10-26**

Goddard Space Flight Center, Greenbelt, MD.

**FLIGHT DYNAMICS TECHNOLOGY**

Ken Galal 301-286-9216

The objective of this RTOP is to develop, evaluate, and demonstrate new technology for flight dynamics in the TDRSS, STS, and SSF era, encompassing algorithms, techniques, software, and system configurations pertaining to attitude and orbit determination/prediction/analysis for both ground-based and onboard applications. Technological advancements in these areas will be aimed at increasing automation and improving accuracy and capability. The technology developed under this RTOP supports the Office of Space Operations in the areas of mission computing and analysis, TDRSS operations, and data processing.

**W93-70529****310-10-60**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ASTROMETRIC DEVELOPMENT TECHNOLOGY**

R. P. Linfield 818-354-2806

(310-10-63)

The objective of this RTOP is to design and demonstrate improved techniques of astrometric data acquisition and analysis as used by the Deep Space Network to support spacecraft navigation. Central to this goal is quantifying and reducing the limiting error sources for various radio and optical tracking data types. Starting from an understanding of the underlying physics, potential error sources are studied to reduce their impact on the final navigation observables. Deep-space navigation is limited by uncertainties in the measurement of components of spacecraft position and velocity in the plane of the sky. Thus a major thrust is the refinement of methods of spacecraft angular measurement using various astrometric techniques, primarily Very Long Baseline Interferometry (VLBI). The accuracy of relative astrometric measurements (across 1 radian or less of the sky) are currently limited by two error sources: fluctuations in tropospheric refractivity (primarily those due to water vapor) and system noise. The former of these two sources will be much more difficult to solve. Thus, in the near term, we will focus a large effort on techniques to reduce the contribution of the troposphere to our error budget. We will also continue an effort to drastically reduce system noise as an error source. To advance the capability for target-relative navigation, improvement of the tie between the planetary ephemeris and the radio reference frame is being pursued using VLBI measurements of planetary orbiters. Evaluation of optical tracking techniques will determine their potential for application to future laser-equipped spacecraft. Both filled-aperture and interferometric devices will be considered. The instruments and errors will be studied, in order to optimize the ultimate performance of the technique. The current focus is on data and error analysis for filled aperture telescopes and design compatibility for the Deep

## OFFICE OF SPACE COMMUNICATIONS

Space Optical Reception Antenna (DSORA) telescope that is being developed in another RTOP.

### W93-70530

310-10-61

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### GPS-BASED DSN CALIBRATION SYSTEM

Stephen M. Lichten 818-354-1614

(310-10-60; 310-10-63)

This RTOP develops and demonstrates the use of the Global Positioning System (GPS) to improve the tracking accuracy and efficiency of the Deep Space Network (DSN) by providing precise Earth platform and media calibrations. The calibrations include Earth orientation parameters, tropospheric path delays, DSN clock synchronization and clock frequency offsets, and geocentric DSN coordinates. Variations in Earth rotation, troposphere delays, and clock parameters can be determined with GPS data with better than sub-hourly resolution, thus allowing for their measurement simultaneously with deep space tracking scans. This simultaneity is generally not available with current non-GPS techniques, especially for calibrations which presently require observations of quasars with the DSN antennas. The use of GPS data for these calibrations will significantly increase the percentage of DSN resources available for deep space tracking and telemetry, while at the same time reducing the amount of DSN antenna time which must be allocated to non-spacecraft measurements such as support and calibration measurements on other sources. The data reduction for these calibrations will also be substantially simplified. This RTOP includes the following: system design; performance analysis; error analysis and parameter estimation software development; study and demonstrations of the use of GPS for DSN calibrations and mission support; and demonstrations of high precision tracking techniques on the GPS satellites and on future earth orbiters. The processing of GPS field data in the system demonstrations carried out in this RTOP utilizes the GPS software also developed under this RTOP. In FY-93, the major focus will be on refining GPS techniques and parameter estimate accuracy, and the exercising and testing of a prototype GPS-based DSN calibrations system.

### W93-70531

310-10-62

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### FREQUENCY AND TIMING RESEARCH

G. John Dick 818-354-6393

(310-10-60; 310-20-64; 310-20-66)

The general objective of this RTOP is to support Deep Space Network (DSN) needs for research in frequency and time generation, distribution, and characterization. A more immediate goal is to advance the art of various technologies being developed to meet the requirements of new missions, e.g., Ka band radio science, and to develop them to a stage where they can be transferred to implementation. The near term work is focused on the following: (1) the development of a DSN capability, from the linear ion trapped frequency source (LIT), for stability of parts in  $10(\text{exp } 16)$  at averaging intervals 100 is less than or equal to  $\tau$  is less than or equal to 10,000 seconds; (2) development of the superconducting cavity maser oscillator (SCMO) for parts in  $10(\text{exp } 16)$  at averaging intervals 1 less than or equal to  $\tau$  is less than or equal to 1000 seconds, and generation of spectrally pure signals at 8.1 and 32 GHz frequencies with the sapphire dielectric resonator oscillator; and (3) the distribution of frequencies and wide-band signals at X- and Ka-band with stability of parts in  $10(\text{exp } 17)$  through the development of fiber-optics systems. The emphasis this year for the trapped ion work is on performance improvement for the newly developed LIT technology and to make this technology more field-worthy. Also, advanced concepts which make possible a greater than or equal to 1 photon/atom signal recovery rate will continue to be pursued for both Mercury and Ytterbium. For the SCMO the emphasis will be on a field-worthy cryogenic configuration and on L.O. capability for improved LIT performance. Our third, and final, focus is on a field demonstration of frequency reference signal transmission capability at Ka-band.

### W93-70532

310-10-63

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

#### SPACE SYSTEMS AND NAVIGATION TECHNOLOGY

Sam W. Thurman 818-354-0976

(310-10-60; 310-10-61; 310-20-67)

The overall objectives of this RTOP are as follows: (1) to increase the accuracy of the end-to-end Deep Space Network (DSN)-based navigation process; (2) to increase the efficiency, reliability, and flexibility of this process; (3) to shape the evolution of DSN-based navigation capabilities to meet future mission needs; and (4) to help flight projects shape their mission plans to effectively utilize anticipated future DSN capabilities. To fulfill these goals, this RTOP formulates and develops new and improved ground-based radio and optical navigation systems and techniques, and navigation data processing systems. In the near-term (FY-93 and FY-94), the objectives of the RTOP are as follows: (1) develop and demonstrate a medium-to-high accuracy (300 to 30 nrad in an angular sense) radio navigation capability that minimizes resource requirements on both flight projects and the DSN; (2) provide system-level requirements analysis, guidance, and applications demonstrations for the development of future ground-based optical navigation systems; and (3) develop and demonstrate graphical user interfaces for orbit determination software systems and prototype software to automate radio metric data processing functions. Within the RTOP, radio navigation techniques are developed for relatively traditional mission types, such as planetary flybys, and for difficult new mission types, such as outer-planet orbiters that execute multiple satellite encounters. Whenever possible, demonstrations of new/improved techniques are performed using actual data from current missions. Navigation accuracies, factors limiting achievable accuracy, and DSN resource utilization required when using various data types for navigation are evaluated in a variety of representative mission scenarios, by means of numerical and analytical studies. Investigations of the navigational benefits of improved error source models and calibration methods are also performed. New navigation concepts for future spacecraft that may use optical communication links are developed, and when possible demonstrations of new technologies and observing techniques are conducted, using stars and natural solar system bodies (asteroids, natural satellites of the planets). The RTOP also endeavors to develop and demonstrate navigation data processing concepts and systems, such as the use of graphical user interfaces to increase the efficiency, flexibility, and reliability of DSN multi-mission navigation and flight project navigation operations; these concepts serve to reduce the cost of navigation-related operations and to maximize the productivity of navigation operations personnel.

### W93-70533

310-20-35

Goddard Space Flight Center, Greenbelt, MD.

#### OPTICAL COMMUNICATIONS

Michael A. Krainak 301-286-2646

Free space intersatellite optical communications systems are a new technology which can provide the high data rates required for the NASA Tracking and Data Relay Satellite System (TDRSS) 2 network and beyond. Optical communications offers a small size, light weight, low power, and low cost alternative to present microwave satellite systems. Two additional advantages from the use of the optical frequencies are the following: (1) immunity to RF interference; and (2) little competition for frequency allocation. The goal of this RTOP is to develop optical communications technology as an improvement to the microwave technology. The near term focus of this RTOP is the development of a Low Earth Orbit (LEO) optical terminal for future Geosynchronous Earth Orbit (GEO)-LEO space communications users. The LEO-GEO links would be from optical terminals on space vehicles or platforms (LEO) to optical terminals on the (GEO) TDRSS 2 system. There are two tasks on this RTOP: (1) the development of a prototype LEO terminal; and (2) the development of a low cost satellite optical communications experiment. The LEO terminal consists of a four inch diameter gimbaled telescope, gimbal controller electronics, IBM PC experiment controller, laser, receiver, interface optics, and mechanical structure. Integration of the LEO terminal

will begin in the 3rd and 4th quarters of FY-92. The integration of the LEO terminal will be complete by early FY-93. The FY-93 RTOP will concentrate on the demonstration and testing of the LEO terminal. A laboratory laser cross link will be established using bench top components and the LEO terminal. The experiment consists of establishing a 50 Mbps optical communications link from earth to LEO satellite to earth. The LEO satellite has an attached optical corner cube retroreflector. The FY-93 RTOP will concentrate on the development of a detailed numerical model of this experiment.

**W93-70534****310-20-36**

Goddard Space Flight Center, Greenbelt, MD.

**PLANNING AND SCHEDULING SYSTEMS TECHNOLOGY**

Karen L. Moe 301-286-5998

The goal of this RTOP is to identify and explore approaches for developing more responsive and more automated planning and scheduling systems for Mission Operations and Data Systems Directorate (MO&DSD). Major objectives are as follows: (1) to identify and evaluate operations concepts from an end-to-end perspective (i.e., from the science user's workstation to the mission spacecraft), addressing system architecture and interface issues; (2) to evaluate technology alternatives including expert systems, operations research and polynomial algorithm techniques, system engineering and human factors, and evaluate existing tools with respect to performance factors and applicability to MO&DSD scheduling problems; (3) to propose a generic planning and scheduling tool set environment for addressing future system requirements; and (4) to develop a planning and scheduling technology testbed for prototyping and demonstrating concepts and tools. This is a system-level RTOP supporting planning and scheduling functions in mission operations, mission support computing, and space network operations.

**W93-70535****310-20-37**

Goddard Space Flight Center, Greenbelt, MD.

**COMMUNICATIONS AND TELEMETRY**

Warner H. Miller 301-286-8183

The objective of this RTOP is to investigate advanced communications systems including: (1) the hardware design of coded transmission systems that are usable in the NASA environment, (2) the theoretical analysis of bandwidth-efficient coded transmission systems, and (3) the transport technology that can be used to support multi-media data from space to ground in a packet mode. The approach for this RTOP is to perform studies, analyses, simulation and the proof-of-concept implementations of advanced communications systems.

**W93-70536****310-20-38**

Goddard Space Flight Center, Greenbelt, MD.

**NETWORKS COMMUNICATION TECHNOLOGY**

T. E. Butler 301-286-7335

The objective of this RTOP is to continue the development of a NASA Communications (Nascom) Open Systems Interconnections (OSI) Protocol (NOSIP) test bed to investigate techniques for interfacing with OSI networks. The objective is being pursued under an OSI protocols task. This task involves analyzing and assessing the relative merits of OSI network technology for application in Nascom networks. The approach for this RTOP is to investigate areas that can provide the maximum benefits to the Division, Directorate, Center, and NASA. The OSI protocols task is structured as a three year effort for analysis, testing, integration, and prototype development. Software development is included. The RTOP effort on this task will culminate in a report, software package, or prototype equipment. Follow-on development work, if any, will use research and development funds.

**W93-70537****310-20-46**

Goddard Space Flight Center, Greenbelt, MD.

**ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS**

R. P. Hockensmith 301-286-9067

The objective of the work under this RTOP is to achieve

technological advances in radio frequency (RF) and optical systems, antenna subsystems and associated control technology, on-board data storage systems, and in telecommunications coding. These developments will satisfy future requirements of users of NASA networks (spacecraft, space platforms, and space transportation system payloads) that require near-global coverage through operational and evolving data relay satellite systems, and other networks as appropriate. The approaches for accomplishing the objective are to: (1) identify the basic operational space flight requirements; (2) investigate active and passive components and antenna systems; (3) investigate methods of reducing and controlling torque noise induced for the steering of large high gain antennas; (4) investigate methods of high density and high rate recording storage and playback; (5) investigate improvements in telecommunication coding of spacecraft generated data; (6) develop system designs to permit user projects to specify proven, reliable hardware with a high confidence level in the performance capability and low cost within the required procurement cycle; and (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

**W93-70538****310-20-64**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ADVANCED TRANSMITTER SYSTEMS DEVELOPMENT**

Rob Hartop 818-354-3433

(310-20-65; 310-20-69)

The objective of this RTOP is the design, development and demonstration of advanced transmitter systems that will enhance performance, reduce costs, and improve the reliability of the Deep Space Network transmitter functions, including uplink command capability, emergency commanding, radio science, navigation, and radar astronomy. The design of a state-of-the-art transmitter system from the output of the frequency standard at 100 MHz or higher to the feedhorn output at X-band (7.2 GHz) or Ka-band (34 GHz) is in progress. This transmitter system will feature advanced technology in several areas, including those that are required for very high phase stability and high reliability, and complete microprocessor monitoring and control. The resulting transmitter technology will be applicable to many NASA anticipated requirements including support for future robotic and manned missions to the Moon and Mars. The focus of this work in FY-93 is the development of a low power Ka-band transmitter suitable for a beam waveguide antenna. Techniques will be developed for combining multiple high power sources while receiving multiple frequencies in an efficient and versatile manner, including beam waveguide antenna environments. Advanced dichroic plates of new design are being developed for frequency separation and simultaneous operation, including up- and downlinks in the same and different frequency bands. A new antenna feed system that will provide simultaneous X- and Ka-band reception will be initiated in FY-93, with an eventual goal of adding X-band uplink as well.

**W93-70539****310-20-65**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ANTENNA SYSTEMS DEVELOPMENT**

Michael A. Thorburn 818-354-1843

(310-20-64; 310-20-69; 310-20-70)

The role of this RTOP is to develop electromagnetic, servo-control, structural, and mechanical technology to increase the capabilities of the large antennas in the Deep Space Network (DSN) for mission support. The focus of the current activities is the new 34-meter beam waveguide antenna, DSS-13, which is the forerunner for the next several antennas to be built in the DSN. Present objectives are to develop multiple frequency band antenna capabilities at DSS-13 over 1 to 45 GHz including: simultaneous dual-frequency and uplink/downlink operations for spacecraft missions; to achieve high accuracy and stable radio frequency (RF) beam pointing at 32 GHz; and to improve effective antenna surface quality at 32 GHz. In addition, recently, extending the lifetime of the 70-meter antennas in the DSN by improving operational reliability and availability has been of considerable interest. To meet these stated objectives, technologies such as mechanical actuation of surfaces and electromagnetic pointing of

the antennas are being developed. To support these developments, the antenna-structural and antenna-electromagnetic analysis, synthesis, and measurement techniques are being improved. Antenna system-level studies are done to prioritize the technologies developed for successful and cost-effective transition to DSN implementation.

**W93-70540****310-20-66**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**RADIO SYSTEMS DEVELOPMENT**

J. Bautista 818-354-6994

(310-20-65; 310-20-64; 310-20-70; 310-20-60)

The objectives of this RTOP are to develop and demonstrate low-noise amplifier technology that will lead to ground-based improvements in spacecraft communications and navigation for deep space missions. The improvements sought are lower noise temperatures, increased bandwidths, reduced implementation costs, and increased reliability of receiving equipment and cryogenic (cooling) systems. These improvements address both present and future Deep Space Network (DSN) navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications downlink is the gain of the receiving antenna divided by the system noise temperature (G/T). This RTOP addresses the challenge of keeping the system noise temperature as low as technology economically permits over the present and future DSN frequency band. The immediate concern of this RTOP is the development of broadband, high gain, low-noise amplifiers at 32.00 and 33.68 GHz which are compatible with the DSN and Ka-band link experiment (KABLE) frequencies. These amplifiers will be compact, economical and compatible with beam waveguide antenna systems. Amplifiers using the principle of microwave amplification by the stimulated emission of radiation (MASER's) and high-electron mobility transistors (HEMT's) are being developed. In FY-93, MASER's and HEMT's will be designed and demonstrated to have noise temperatures below 4 K and 9 K (referenced to the amplifier input), respectively. In addition, to protect HEMT's from radio frequency interference (RFI), filters utilizing high temperature superconductors will continue to be developed. The analytical tools and measurement systems needed to characterize the associated materials and devices for the design of practical amplifiers are continuing to be developed. There is also a continuing effort to develop a more reliable 1.6 K cooling system appropriate for use on antennas with beam waveguide feed systems to greatly improve maser performance. For example, on cooling an 8.4 GHz maser from 4.5 K to 1.6 K the gain in dB increases three times while the noise temperature is reduced by a factor of three.

**W93-70541****310-20-67**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT**

James R. Lesh 818-354-2766

(310-10-63; 310-20-60; 506-72-31; 315-91-60)

The objective of this RTOP is to develop and demonstrate reliable and efficient optical communications and tracking capability for use with Deep Space Network (DSN) supported missions of the future. The work will concentrate on the definition, design, development, and analysis of communications and tracking systems that could support such missions, and will include the development of high-leverage technologies that have a major influence on the character of those systems. This RTOP will involve the design, development, fabrication, and testing of laboratory and other ground-based demonstrations of the technology for optical communications and tracking. Flight demonstrations of the technology will be pursued only through the conceptual design and planning stages, so that appropriate justification, flight-ground architectural needs, and sources of funding can be identified for the execution of the flight demonstrations. Optical techniques for communication and tracking are expected to be of greatest value when used between planetary spacecraft and an Earth-orbiting communications and tracking terminal. However, studies indicate that even ground-based optical systems could provide communications and tracking performance that exceeds current

DSN capabilities by at least 10 dB. Accordingly, this RTOP will focus initially on the design, cost, and performance factors of ground-based systems. These studies will emphasize identification of the key factors which determine performance, as well as estimation of the uncertainties in those factors. Major activities for the RTOP during FY-93 are the definition and planning for a ground-based research and development facility, establishment of a network of three autonomous atmospheric visibility monitoring (AVM) telescopes for the formulation and validation of an atmospheric weather model, and definition of an interim ground terminal for supporting near-term space demonstrations of optical communication technology.

**W93-70542****310-30-69**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**DSS 13 INSTRUMENTATION AND CAPABILITIES**

Mark Gatti 818-354-2123

(310-20-66; 310-10-62; 310-20-65; 310-30-71; 310-10-60; 310-20-64; 310-30-70)

The objective of this RTOP is to provide the core equipment and capabilities for the Deep Space Network research and development station (DSS 13) 34-meter beam waveguide antenna. This equipment must support a multiplicity of users both internal and external to the Advanced Systems Program. It is important to support these user activities since many of these activities are precursors to future DSN capabilities, enhancements, and increased efficiencies. Hence a critical element of this RTOP is the demonstration of new and emerging antenna, receiver and station technologies, particularly as they apply to the new 32 GHz downlink DSN frequency band (Ka-band). General objectives include providing for antenna calibrations, water vapor radiometers, low noise amplifiers, digital receivers, feeds and front-ends, and monitor and control. Certain capabilities, of interest only to single users, will be provided by those users. At the end of such a research program, an agreement may be reached whereby this new capability is absorbed into the core facility of DSS 13 and support for the capability is continued. Also, there is a work unit which will provide engineering support to users, and to the station personnel in the event of component failure. Core capabilities will be implemented in a timely manner consistent with the future goals for the anticipated use of the facility. The major near-term objectives are to provide simultaneous 2.3/8.5 GHz (S/X-band) receive for Very Long Baseline Interferometry (VLBI) and radar, and the plan to decommission the existing 26-meter antenna. The core capabilities include the S/X-band receive strings, X/Ka-band receive strings, precision pointing, and monitor and control. The core capabilities to be provided by this RTOP will be realized through the close cooperation and careful coordination of the efforts of related RTOPs, and by anticipating the future needs of the facility. In this way the new technologies to be used in the DSN may be sufficiently tested in a well supported research and development environment.

**W93-70543****310-30-70**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**NETWORK SIGNAL PROCESSING**

Sami Hinedi 818-354-3016

(310-30-65; 310-30-66; 310-30-69; 310-30-72)

The purpose of the RTOP is to investigate, develop, test and demonstrate advanced signal processing systems which enable the Deep Space Network (DSN) to plan and achieve current and future performance requirements with improved reliability, maintainability and operability. Key objectives of the RTOP are: (1) develop and demonstrate signal processing techniques and algorithms for a Ka-band array feed in order to reduce gravity-induced antenna gain losses; (2) develop and demonstrate techniques for generating array feed error signals to provide electronic antenna pointing capability at Ka-band; (3) develop and demonstrate a telemetry arraying system that is capable of performing various combining techniques on recorded spacecraft data; (4) develop high speed sampling and digitizing circuits to enable wider bandwidth front-end digital signal processing; (5) develop custom Very Large Scale Integrated (VLSI) circuits for

signal processing whenever cost, speed, complexity, size and reliability dictate; and (6) develop parallel receiver architectures for high data rate telemetry links. The work outlined in this RTOP will be achieved by exploiting advanced Digital Signal Processing (DSP) technologies and algorithms, including general purpose and custom VLSI chips. Field testing of items (1) to (3) will be performed at the DSN research and development station, DSS-13. During FY-93, the main tasks are: (1) to conduct a cooled demonstration of the Ka-band array feed including combining and tracking; (2) to investigate applications of the Compact Digital Signal Processor (CDSP) chip in DSN systems; (3) to design a telemetry system using parallel architectures; (4) to document the 1-bit radio frequency digitizer (RFD) and investigate application of a 6-bit RFD; (5) to support the Ka-band link experiment (KABLE) with the Mars Observer spacecraft; (6) to investigate low symbol signal-to-noise ratio (SNR), low symbol rate acquisition; (7) to add open-loop recording capability to the advanced receivers; (8) to investigate automatic frequency control (AFC) for DSN applications; and (9) to initiate the development and demonstration of a telemetry array system. The development of the new DSN spectrum surveillance system has been completed and the work unit has been transferred to another RTOP.

**W93-70544****310-30-71**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**COMMUNICATION SYSTEMS RESEARCH**

Fabrizio Pollara 818-354-4287

(310-30-70)

The objective of this RTOP is to perform communication systems research required to meet the needs of present and future Deep Space Network (DSN) supported missions. This effort is focused on improving space communication capability at low cost, through research and development in key areas of coding and modulation for efficient data transmission, including up-link command coding. The work planned will involve five areas. First, coding/decoding (error-correcting and source) and modulation/demodulation techniques for future missions will be investigated and demonstrated. The near term goals include the development of low-complexity, high fidelity image compression schemes and the performance/complexity analysis of recently discovered codes. The longer-term goal involves new research into channel codes and source codes for improved data returns within power and bandwidth limits. Second, communication efficiency will be improved for current codes and technology. For example, sometimes changes in decoding techniques can improve error performance for already existing codes. Much of this work uses previously developed analysis and computer simulations in evaluating proposed and planned changes in hardware or operations; the development of these simulations is an ongoing activity of this RTOP. Third, coding ideas developed and/or analyzed in this RTOP will be demonstrated, and recommendations will be made on their potential use. Fourth, technical support for implementation of the Big Viterbi Decoder, designed under this RTOP, will be provided. Fifth, DSN system engineering analysis will support flight demonstrations and planning to test technologies in related RTOPs, accelerate technology transfer to implementation, and characterize operational performance of future systems, especially for Ka-band.

**W93-70545****310-40-37**

Goddard Space Flight Center, Greenbelt, MD.

**HUMAN-TO-MACHINE INTERFACE TECHNOLOGY**

Walt Truskowski 301-286-8821

The objectives of this RTOP are to realize developmental and operational improvements in user/machine interfaces and interactions in control center and data processing systems by identifying, researching, and developing state-of-the-art concepts, models, and tools for supporting the engineering of these interfaces and interactions. The intent is to apply recent advances in human factors analysis, data and information base management, semantic modelling, and artificial intelligence (AI) to human/machine interface and interaction problems in order to realize the desired improvements. The approach to be followed in realizing the

objectives is to provide tools and environments to support the evaluation, and use of operational interfaces. The evaluation will be supported by a tool designed to provide guideline-based evaluations of human/computer interfaces. Intelligent Tutoring Systems will provide training to both managers and technicians in the proper use of their respective systems. A systematic evaluation of operational graphical interfaces will be carried out as part of a major technology transfer process. This RTOP is a system level RTOP on mission operations, mission support computing, and general systems engineering activities.

**W93-70546****310-40-45**

Goddard Space Flight Center, Greenbelt, MD.

**MISSION OPERATIONS TECHNOLOGY**

Dan Mandl 301-286-4323

Typical functions performed by a Flight Operations Team (FOT) under the pressure of a timeline are to monitor and analyze large amounts of telemetry data from a host of instruments and platforms, diagnose and predict subsystem failures, and develop strategies for corrective action. Expert systems and other automation techniques have been developed to help the FOT perform their increasingly complex tasks reliably and quickly. Examples of such systems are the Graphical Spacecraft Monitoring System (GSMS) and the Expert System Predictor (ESP), two systems developed for the Gamma Ray Observatory (GRO) Payload Operations Control Center (POCC). These systems use state-of-the-art two and three dimensional realtime color graphics, expert system techniques, and neural networks to assist the FOT in determining the spacecraft health and safety. POCC systems are now evolving to workstation based technology which provides increased performance, enhanced user interfaces, and physical portability. With the increased power of workstations comes ever increasing complexity in the software development and more requests for changes, thereby increasing costs. The objective of this RTOP is to encapsulate selected POCC functions and create reusable building blocks which will be used to enhance the Transportable Payload Operations Control Center (TPOCC) core functions. In addition, a mechanism will be developed to incorporate externally developed products into the TPOCC environment. This will be demonstrated by seamlessly integrating GSMS and ESP into the TPOCC environment.

**W93-70547****310-40-47**

Goddard Space Flight Center, Greenbelt, MD.

**EXPERT SYSTEMS FOR AUTOMATION OF OPERATIONS**

Walt Truskowski 301-286-8821

Work under this RTOP will demonstrate the potential of expert systems to automate operations and increase operator capacity by handling routine, labor-intensive tasks and by reducing human task complexity. The development and demonstration of pilot projects which capture functions of control centers will facilitate the transfer of this technology into operations. Under this RTOP, expert systems will be developed and applied in selected areas to reduce, eliminate, or assist human operator decision-making. Projects will be established with the operational divisions to develop proof-of-concept systems and transfer the technology for operational use. Systems will be developed with a phased approach to allow for early hands-on demonstration of kernel functions to potential users. The transfer of techniques, methodologies, and expertise to the operational divisions will be a major goal. This RTOP will also address some of the knowledge management issues associated with both single and multiple cooperating expert systems, and will generalize from specific prototypes to multi-application frameworks. It will also support the embedding of expert systems in data systems.

**W93-70548****310-40-48**

Goddard Space Flight Center, Greenbelt, MD.

**DATA STORAGE TECHNOLOGY**

Ward Horner 301-286-5804

The objectives are to develop systems technology and to evaluate storage components to provide high performance, low life cycle cost data storage systems to meet data capture, buffering,

## OFFICE OF SPACE COMMUNICATIONS

processing, and distribution requirements for future space missions. Commercial tape and disk subsystems have evolved functional, performance, and cost characteristics which now make them candidates in the development of high performance, cost effective Level Zero Positioning (LZP) systems. These systems require the use of commercially available disk farms with appropriate failure mode control to ensure data integrity. NASA specific very large scale integration (VLSI) controllers for management of spacecraft telemetry processing and flow will be developed for use with commercial parallel disk controllers, disk drives, and standard interfaces. These elements will be used to prototype advanced LZP system architectures adaptable to a range of mission data rates.

**W93-70549**

**310-40-49**

Goddard Space Flight Center, Greenbelt, MD.

### **ADVANCED ENVIRONMENTS FOR SOFTWARE AND SYSTEM DEVELOPMENT**

Sylvia B. Sheppard 301-286-5049

The goal of this RTOP is to develop and evaluate systems-level concepts and technologies that will be used to optimize the development, operation, management and evolution of Mission Operations and Data Systems Directorate (MO&DSD) data systems. Major objectives are (1) the development of a state-of-the-art performance modeling environment consisting of an integrated set of tools and support services to facilitate the use (and reuse) of data system modeling, and (2) the definition and phased prototyping of an advanced software engineering environment. The approach is to develop or acquire associated tools and techniques, apply the tools and techniques to representative problems, and evaluate both the techniques and the results prior to full utilization in MO&DSD. This is a system-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and Tracking and Data Relay Satellite System (TDRSS) operations.

**W93-70550**

**310-40-51**

Goddard Space Flight Center, Greenbelt, MD.

### **ADVANCED TELEMETRY PROCESSING TECHNOLOGY**

James A. Pritchard 301-286-7785

Work under this RTOP will evaluate alternative approaches to high data rate packet telemetry processing for parallel and non-parallel computer architecture developments applicable to the Space Station era data systems. Current packet telemetry processing systems need to be improved by as much as three orders of magnitude in order to handle the expected data rates. New computer and system architectures and processing techniques must be explored and evaluated if new systems are to be developed to meet Space Station era processing requirements. This RTOP will evaluate alternative approaches to telemetry processing (Level Zero Processing and data handling functions) for parallel and non-parallel computer architecture, study high levels of telemetry processing, and study telemetry processing system architecture requirements for Space Station era data systems. In order to evaluate alternative approaches to telemetry processing, computer architecture will be matched to high data rate telemetry processing requirements. Critical telemetry functions will be selected for benchmarking, and computer architecture performance will be evaluated. Programming techniques and software conversion will also be evaluated. Level Zero Processing as well as higher levels of telemetry processing will be considered while investigating telemetry processing system architecture requirements. In order to accomplish the above tasks, benchmarking of critical processing functions will be employed whenever possible.

**W93-70551**

**310-40-73**

Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### **DSN DATA PROCESSING AND PRODUCTIVITY**

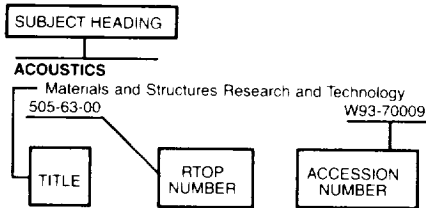
Lynne P. Cooper 818-306-6145

(310-30-69)

The objective of this RTOP is to develop and demonstrate advanced computer information processing technologies to improve the capability of the Deep Space Network (DSN) to meet user

needs, including: (1) increasing the availability of the DSN to support increased mission sets; (2) reducing system development costs and risk; (3) increasing the predictability, reliability, and efficiency of service; (4) increasing the overall ease of operating the DSN; and (5) improving performance and security of end-to-end data delivery. The work units in this RTOP fall into two basic areas. (1) Operability, Automation, and Support: In this area, advanced information processing technologies are applied to improve the way that the DSN currently operates. Work units address automation of monitor and control functions, and the extensibility of Knowledge-Based Systems (KBS) to meet the full scope of operational needs, including embedded training, automated scheduling, and subsystem automation guidelines. (2) DSN End-to-End Architecture: The overall data delivery capability of the DSN is dependent upon efficient high speed data processing, transfer, and storage. Work units in this area address the evaluation, adaptation, and adoption of Open Systems Interconnect (OSI) and other standards for communications and storage, end-to-end architectural evaluation, Wide Area Networking technology, and high speed telemetry support. Two other work units, Data Flow Simulation and Software Engineering Project Management Simulation, are in the process of technology transfer. These work units are completing calibration and validation phases prior to being turned over to user organizations.

### Typical Subject Index Listing



Listings in this index are arranged alphabetically by subject heading. The subject heading is a key to the subject content of the document. The title is used to provide a more exact description of the subject matter. The RTOP number and accession number are included in each entry to assist the user in locating the citation and technical summary in the summary section. The titles are arranged under each subject heading in ascending accession number order.

## A

### ABIOTENESIS

Exobiology Intact Capture Technology Development  
199-52-54 W93-70250

### ABLATION

Earth-to-Orbit Transportation  
584-03-00 W93-70121

### ABSORPTION CROSS SECTIONS

Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379

### ABSORPTION SPECTRA

Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156

Deep Optical/UV Imaging of Quasars Below the Lyman  
Limit  
188-41-21 W93-70183

IR Solar Absorption Spectra  
464-12-05 W93-70368

NDSC Differential Absorption Lidar  
464-13-15 W93-70371

Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

Laser Laboratory Spectroscopy  
464-23-09 W93-70382

Measurement of Volcanic Gases  
465-44-05 W93-70414

### ABSORPTION SPECTROSCOPY

Planetary Materials: Chemistry  
152-13-40 W93-70144

Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156

Laser Diode Sensor  
464-11-07 W93-70366

Laser Laboratory Spectroscopy  
464-23-09 W93-70382

### ACCELERATED LIFE TESTS

Materials and Structures Research and Technology  
506-43-00 W93-70077

### ACCELERATION (PHYSICS)

Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178

Ground Experiment Operations  
674-28-08 W93-70519

### ACCRETION DISKS

Solar System Studies  
151-01-60 W93-70138

Simulations of Compact Radio Sources  
188-44-53 W93-70198

Planet-Forming Disks  
452-21-93 W93-70302

### ACCURACY

Optical Interferometry in Space  
188-78-41 W93-70213

### ACETYLENE

Ground-Based Infrared Astronomy  
196-41-50 W93-70218

### ACOUSTIC PROPERTIES

Advanced Rotorcraft Technology  
532-06-00 W93-70040

Emissions and Source Noise  
537-02-00 W93-70054

### ACOUSTICS

Materials and Structures Research and Technology  
505-63-00 W93-70009

Advanced Rotorcraft Technology  
532-06-00 W93-70039

Advanced Turboprop Systems  
535-03-00 W93-70045

### ACOUSTO-OPTICS

Science Sensing (Remote)  
582-03-00 W93-70111

Imaging Spectropolarimeter  
157-03-70 W93-70170

### ACTIVE CONTROL

Aerodynamics Research and Technology  
505-59-00 W93-70003

Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059

In-Space Technology Experiments  
506-74-00 W93-70104

In-Space Experiments  
506-74-00 W93-70105

### ACTIVE GALACTIC NUCLEI

Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204

### ACTIVE GALAXIES

High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210

### ACTIVITY (BIOLOGY)

Structural Biosystems  
199-40-42 W93-70242

ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499

### ACTUATORS

Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059

Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060

Information and Controls Research and Technology  
506-59-00 W93-70089

Earth-Orbiting Platforms  
585-03-00 W93-70126

### ADAPTATION

Longitudinal Studies (Medical Operations Longitudinal  
Studies)  
199-02-31 W93-70224

Behavior and Performance Research  
199-06-11 W93-70230

Cell and Development Biology  
199-40-21 W93-70239

### ADAPTIVE CONTROL

Information and Controls Research and Technology  
506-59-00 W93-70091

Automation and Robotics  
586-02-00 W93-70132

### ADHESION

Materials and Structures Research and Technology  
506-43-00 W93-70073

### ADIABATIC CONDITIONS

Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195

### ADIABATIC DEMAGNETIZATION COOLING

Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195

### ADRIATIC SEA

Scatterometer Studies  
461-31-13 W93-70324

### ADSORPTION

Mars Surface and Atmosphere Studies  
155-04-00 W93-70162

### ADVANCED VERY HIGH RESOLUTION RADIOMETER

Space Data Systems  
586-03-00 W93-70136

Biosphere Atmospheric Interactions  
428-81-26 W93-70265

Global Assessment of Active Volcanism  
428-81-94 W93-70269

Studies of Volcanic SO<sub>2</sub>  
428-81-99 W93-70271

Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274

Biosphere Atmospheric Interactions  
429-81-26 W93-70279

Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282

Global Assessment of Active Volcanism  
429-81-94 W93-70285

Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289

Foreign Visitor Support  
429-97-04 W93-70290

Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321

Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356

Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426

Global Monthly Mean Ocean Variability  
578-22-29 W93-70435

Active/Passive Sea Ice Analysis  
578-32-24 W93-70437

Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438

Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440

Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468

Spatial and Temporal Distribution of Biomass  
Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472

### AERIAL RECONNAISSANCE

Validation of Volcanic Plume Models with Remote  
Sensing  
465-44-04 W93-70413

Airborne Science Management Operating Working  
Group Support  
465-66-00 W93-70418

### AEROACOUSTICS

Applied Aerodynamics Research and Technology  
505-59-00 W93-70001

Interdisciplinary Technology  
505-90-00 W93-70024

Advanced Rotorcraft Technology  
532-06-00 W93-70040

Emissions and Source Noise  
537-02-00 W93-70055

### AEROASSIST

Materials and Structures Research and Technology  
506-43-00 W93-70071

### AEROBRAKING

Aerothermodynamics Research and Technology  
506-40-00 W93-70063

### AERODYNAMIC CHARACTERISTICS

Aerodynamics Research and Technology  
505-59-00 W93-70002

Propulsion and Power  
505-62-00 W93-70005

Hypersonic Research and Technology  
505-70-00 W93-70020

Hypersonic Training and Research  
505-70-00 W93-70021

Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047

Aerothermodynamics Research and Technology  
506-40-00 W93-70062

Aerothermodynamics Research and Technology  
506-40-00 W93-70063



# AERODYNAMIC CONFIGURATIONS

# SUBJECT INDEX

Science Sensing (Remote) W93-70110

**AERODYNAMIC CONFIGURATIONS**

Advanced Rotorcraft Technology W93-70040

**AERODYNAMIC LOADS**

Advanced Rotorcraft Technology W93-70039

Materials and Structures Research and Technology W93-70074

**AERODYNAMIC NOISE**

Advanced Rotorcraft Technology W93-70040

**AERODYNAMIC STABILITY**

In-Space Technology Experiments W93-70106

**AERODYNAMICS**

Applied Aerodynamics Research and Technology W93-70001

Aerodynamics Research and Technology W93-70002

Aerodynamics Research and Technology W93-70003

Systems Analysis W93-70019

Hypersonic Research and Technology W93-70023

Computational Aerosciences W93-70029

Earth and Space Sciences W93-70032

Earth and Space Sciences W93-70034

Earth and Space Sciences W93-70035

Advanced Turboprop Systems W93-70045

Hypersonic Research and Technology W93-70101

Cosmic and Heliospheric Physics W93-70176

Ground-Based Support of Solar Physics W93-70179

Center of Excellence for Space Data Information Sciences (CESDIS) W93-70491

**AEROELASTICITY**

Materials and Structures Research and Technology W93-70006

Materials and Structures Research and Technology W93-70008

Materials and Structures Research and Technology W93-70009

**AEROMAGNETISM**

Problems in Interpreting Satellite Crustal Anomaly Field Data W93-70456

**AEROMANEUVERING**

Information and Controls Research and Technology W93-70092

**AERONAUTICAL ENGINEERING**

Systems Analysis W93-70017

Systems Analysis W93-70019

Hypersonic Training and Research W93-70021

Interdisciplinary Technology W93-70024

Interdisciplinary Technology W93-70025

Interdisciplinary Technology W93-70026

Interdisciplinary Technology W93-70027

Numerical Aerodynamic Simulation (NAS) W93-70047

NAS Operations W93-70048

Human Support Research and Technology W93-70095

Science Sensing (Remote) W93-70112

**AERONAUTICS**

Systems Analysis W93-70017

**AERONOMY**

Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies) W93-70173

**AEROSOLS**

Science Sensing (Remote) W93-70110

Planetary Atmospheric Composition, Structure, and History W93-70152

Planetary Clouds Particulates and Ices W93-70155

Studies of Cloud Processes on the Outer Planets W93-70158

Micro Weather Stations for Mars W93-70174

Global Assessment of Active Volcanism W93-70270

CO2 Lidar Backscatter Experiment W93-70309

Airborne Doppler Lidar W93-70311

Lidar Target Calibration Facility W93-70312

Atmospheric Backscatter Experiment W93-70313

Wind Measurement Assessment W93-70314

Land Surface Climatology: HAPEX W93-70340

Heterogeneous Scene Models W93-70347

Chemical Kinetics of the Stratosphere W93-70376

Satellite Observations of Volcanic Aerosols W93-70410

Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption W93-70415

Climate Modeling with Emphasis on Aerosols and Clouds W93-70422

Two-Dimensional Stratospheric Chemical Model - Radiation W93-70451

**AEROSPACE ENGINEERING**

Interdisciplinary Technology W93-70025

Interdisciplinary Technology W93-70026

Interdisciplinary Technology W93-70027

Computational Aerosciences W93-70028

Computational/Aeroscience W93-70031

Earth and Space Sciences W93-70032

Earth and Space Sciences W93-70034

Earth and Space Sciences W93-70035

Numerical Aerodynamic Simulation (NAS) W93-70047

NAS Operations W93-70048

Materials and Structures Research and Technology W93-70072

Space Flight Research and Technology W93-70078

Systems Analysis W93-70082

University Space Engineering Research W93-70086

Information and Controls Research and Technology W93-70089

Human Support Research and Technology W93-70095

In-Space Technology Experiments W93-70107

Science Sensing (Remote) W93-70112

Surface Systems W93-70116

Information and Communications W93-70137

Cosmic and Heliospheric Physics W93-70176

Flight Research W93-70244

Center of Excellence for Space Data Information Sciences (CESDIS) W93-70491

**AEROSPACE ENVIRONMENTS**

Materials and Structures Research and Technology W93-70073

Space Flight Research and Technology W93-70079

In-Space Technology Experiments W93-70106

Space Data Systems W93-70136

Planetary Materials: Surface and Exposure Studies W93-70147

Ground-Based Support of Solar Physics W93-70179

Radiation Health W93-70226

Behavior, Performance and Human Factors W93-70231

Cell and Development Biology W93-70239

Flight Research W93-70243

**AEROSPACE INDUSTRY**

Interdisciplinary Technology W93-70027

Computational Aerosciences W93-70030

Materials and Structures Research and Technology W93-70071

**AEROSPACE MEDICINE**

Clinical Medicine Technology Watch W93-70223

Longitudinal Studies (Medical Operations Longitudinal Studies) W93-70224

Behavior and Performance Research W93-70230

Regulatory Physiology (Biomedical) W93-70235

Musculoskeletal W93-70238

**AEROSPACE PLANES**

Controls, Guidance and Human Factors Research and Technology W93-70012

**AEROSPACE SAFETY**

Information and Controls Research and Technology W93-70092

In-Space Technology Experiments W93-70103

Information and Communications W93-70134

Behavior and Performance Research W93-70230

Neuroscience (Biomedical) W93-70234

Regulatory Physiology (Biomedical) W93-70235

**AEROSPACE SCIENCES**

Computational Aerosciences W93-70028

Computational Aerosciences W93-70029

Earth and Space Sciences W93-70033

Earth and Space Sciences W93-70034

Information Systems Newsletter W93-70477

**AEROSPACE SYSTEMS**

Materials and Structures Research and Technology W93-70071

Materials and Structures Research and Technology W93-70075

Space Flight Research and Technology W93-70079

Systems Analysis W93-70082

Systems Analysis W93-70084

University Space Engineering Research W93-70086

Information and Controls Research and Technology W93-70088

Information and Controls Research and Technology W93-70089

Information and Controls Research and Technology W93-70091

Information and Controls Research and Technology W93-70092

In-Space Technology Experiments W93-70103

Science Sensing (Remote) W93-70109

Observatory Systems W93-70114

Earth-to-Orbit Transportation W93-70118

Automation and Robotics W93-70129

Space Data Systems W93-70136

Information and Communications W93-70137

Data Interchange Standards W93-70479

Advanced Space Systems for Users of NASA Networks W93-70537

**AEROSPACE TECHNOLOGY TRANSFER**

- Propulsion Research and Technology  
506-42-00 W93-70069
- Information and Controls Research and Technology  
506-59-00 W93-70089

**AEROSPACE VEHICLES**

- Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047
- NAS Operations  
536-02-00 W93-70048
- Aerothermodynamics Research and Technology  
506-40-00 W93-70062
- Aerothermodynamics Research and Technology  
506-40-00 W93-70063
- In-Space Technology Experiments  
506-74-00 W93-70103
- Information and Communications  
586-03-00 W93-70135

**AEROTHERMODYNAMICS**

- Hypersonic Training and Research  
505-70-00 W93-70021
- Aerothermodynamics Research and Technology  
506-40-00 W93-70062
- Aerothermodynamics Research and Technology  
506-40-00 W93-70063
- Materials and Structures Research and Technology  
506-43-00 W93-70074
- Hypersonics Research and Technology  
506-73-00 W93-70100
- Hypersonic Research and Technology  
506-73-00 W93-70101

**AFRICA**

- Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321
- Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
579-42-02 W93-70468

**AGGLOMERATION**

- Glasses and Ceramics  
674-26-05 W93-70515

**AGGREGATES**

- Microgravity Nucleation and Particle Coagulation Experiments  
152-20-01 W93-70148

**AGRICULTURE**

- ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342
- Soil Moisture from SAR  
462-62-05 W93-70349

**AIR BREATHING ENGINES**

- Propulsion and Power  
505-62-00 W93-70005
- Systems Analysis  
505-69-00 W93-70018
- Hypersonic Research and Technology  
505-70-00 W93-70020
- Hypersonic Training and Research  
505-70-00 W93-70021
- Hypersonic Research and Technology  
505-70-00 W93-70022
- Hypersonics Research and Technology  
506-73-00 W93-70100

**AIR DATA SYSTEMS**

- Flight Systems Research and Technology  
505-68-00 W93-70013

**AIR FLOW**

- High Performance Flight Research  
533-02-00 W93-70042

**AIR LAND INTERACTIONS**

- Global Hydrologic Cycle  
429-81-16 W93-70278
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- Desert Mesoscale/PBL  
461-13-02 W93-70322
- Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338
- Rapid Earth Orientation Changes  
579-36-10 W93-70462
- Biogeochemistry and Geophysics Modeling and Data Analysis  
579-42-01 W93-70467

**AIR MASSES**

- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375

**AIR POLLUTION**

- Atmospheric Effects  
537-01-00 W93-70052
- Emissions and Source Noise  
537-02-00 W93-70053
- Global Assessment of Active Volcanism  
428-81-96 W93-70270

- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- Simulation of Tropospheric Ozone  
579-24-00 W93-70453
- Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- Climatological Stratospheric Modeling  
579-24-09 W93-70455

**AIR PURIFICATION**

- Human Support Research and Technology  
506-71-00 W93-70093

**AIR SAMPLING**

- Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454

**AIR SEA ICE INTERACTIONS**

- Active/Passive Sea Ice Analysis  
578-32-24 W93-70437

**AIR TRAFFIC CONTROL**

- Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010
- Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012

**AIR WATER INTERACTIONS**

- Cosmic and Heliospheric Physics  
170-10-10 W93-70177
- The Early Evolution of Life  
199-52-32 W93-70248
- Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
428-81-10 W93-70263
- Global Hydrologic Cycle  
428-81-16 W93-70264
- Biosphere Atmospheric Interactions  
428-81-26 W93-70265
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface  
428-81-80 W93-70268
- Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277
- Global Hydrologic Cycle  
429-81-16 W93-70278
- IDS Science for WHOI/GSFC Eos Project  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- IR Remote Sensing of SST  
460-21-28 W93-70310
- Radiative Effects in Clouds First International Satellite Cloud Climatology Regional Experiment  
460-42-00 W93-70315
- Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325
- Airborne ESTAR  
461-38-01 W93-70327
- TRMM  
461-38-05 W93-70329
- GEWEX Program Support  
461-50-03 W93-70331
- Airborne Precipitation Radar  
461-51-16 W93-70332
- Oceanic Remote Sensing Library  
461-66-16 W93-70335
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- Climate Stability: The Role of the Hydrological Cycle and the Thermohaline Circulation  
578-31-14 W93-70436
- An Ocean General Circulation Model for Climate Studies  
578-41-43 W93-70443
- Modeling and Data Analysis, Climate and Hydrology Cryosphere Studies  
578-90-00 W93-70445

**AIRBORNE EQUIPMENT**

- Space Data Systems  
586-03-00 W93-70136
- Laboratory Astrophysics  
188-44-57 W93-70201
- Airborne Doppler Lidar  
460-21-52 W93-70311
- Atmospheric Backscatter Experiment  
460-22-53 W93-70313
- Scatterometer Research  
461-31-09 W93-70323
- Airborne Precipitation Radar  
461-51-16 W93-70332
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Polarimetric Data Analysis  
461-64-11 W93-70334

- Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336
- Soil Moisture from SAR  
462-62-05 W93-70349
- Airborne Synthetic Aperture Radar (AIRSAR) Operations  
462-75-62 W93-70351
- AVIRIS Operations  
463-75-63 W93-70364
- Stratospheric Processes and Atmospheric Chemistry Studies  
464-14-00 W93-70373
- Microwave Temperature Profiler  
464-14-20 W93-70374
- Global Tropospheric Experiment Aircraft, Measurements  
464-54-00 W93-70387
- Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411
- AVIRIS Operations  
465-65-01 W93-70417
- Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418
- Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420
- ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

**AIRBORNE LASERS**

- Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358

**AIRBORNE RADAR**

- Science Sensing (Remote)  
582-03-00 W93-70110

**AIRBORNE/SPACEBORNE COMPUTERS**

- Information and Communications  
586-03-00 W93-70135
- Information and Communications  
586-03-00 W93-70137

**AIRCRAFT ACCIDENTS**

- Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**AIRCRAFT COMMUNICATION**

- Systems Analysis  
505-69-00 W93-70017

**AIRCRAFT CONFIGURATIONS**

- Advanced Turboprop Systems  
535-03-00 W93-70045

**AIRCRAFT CONSTRUCTION MATERIALS**

- Materials and Structures Research and Technology  
505-63-00 W93-70006
- Materials and Structures Research and Technology  
505-63-00 W93-70007
- Materials and Structures Research and Technology  
505-63-00 W93-70008
- Hypersonic Training and Research  
505-70-00 W93-70021
- Advanced Composite Materials Technology  
510-02-00 W93-70038
- Materials and Structures Research and Technology  
506-43-00 W93-70073

**AIRCRAFT CONTROL**

- Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010
- Flight Systems Research and Technology  
505-68-00 W93-70014
- Flight Systems Research and Technology  
505-68-00 W93-70015
- Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059
- Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060

**AIRCRAFT DESIGN**

- Applied Aerodynamics Research and Technology  
505-59-00 W93-70001
- Propulsion and Power  
505-62-00 W93-70005
- Materials and Structures Research and Technology  
505-63-00 W93-70006
- Materials and Structures Research and Technology  
505-63-00 W93-70009
- Systems Analysis  
505-69-00 W93-70017
- Computational/Aeroscience  
509-10-00 W93-70031
- Advanced Composite Materials Technology  
510-02-00 W93-70038
- High-Performance Flight Research  
533-02-00 W93-70041
- Advanced Turboprop Systems  
535-03-00 W93-70045

**AIRCRAFT ENGINES**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
Flight Systems Research and Technology  
505-68-00 W93-70014  
Systems Analysis  
505-69-00 W93-70018  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
High-Performance Flight Research  
533-02-00 W93-70041  
Advanced Turboprop Systems  
535-03-00 W93-70044  
Advanced Turboprop Systems  
535-03-00 W93-70045  
Emissions and Source Noise  
537-02-00 W93-70055

**AIRCRAFT FUELS**

Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012

**AIRCRAFT GUIDANCE**

Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010  
Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70011

**AIRCRAFT ICING**

Flight Systems Research and Technology  
505-68-00 W93-70014

**AIRCRAFT INDUSTRY**

Aerodynamics Research and Technology  
505-59-00 W93-70002  
Propulsion and Power  
505-62-00 W93-70005  
Materials and Structures Research and Technology  
505-63-00 W93-70009  
Systems Analysis  
505-69-00 W93-70016  
Systems Analysis  
505-69-00 W93-70018  
Systems Analysis  
505-69-00 W93-70019  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Hypersonic Research and Technology  
505-70-00 W93-70023  
Advanced Composite Materials Technology  
510-02-00 W93-70037  
Advanced Composite Materials Technology  
510-02-00 W93-70038  
Atmospheric Effects  
537-01-00 W93-70052  
Emissions and Source Noise  
537-02-00 W93-70055  
Community Noise and Sonic Boom  
537-03-00 W93-70057  
Hypersonics Research and Technology  
506-73-00 W93-70100  
Hypersonic Research and Technology  
506-73-00 W93-70101

**AIRCRAFT INSTRUMENTS**

Science Sensing (Remote)  
582-03-00 W93-70110  
Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274  
Process Studies: Radiation Dynamics and Hydrology, Radiation and Dynamic Processes  
460-20-00 W93-70308  
Hydrologic Process Studies  
461-50-00 W93-70330

**AIRCRAFT MAINTENANCE**

Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012

**AIRCRAFT MANEUVERS**

Propulsion and Power  
505-62-00 W93-70005  
Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010  
Flight Systems Research and Technology  
505-68-00 W93-70013  
Flight Systems Research and Technology  
505-68-00 W93-70015  
High Performance Flight Research  
533-02-00 W93-70042

**AIRCRAFT NOISE**

Advanced Rotorcraft Technology  
532-06-00 W93-70039

Advanced Rotorcraft Technology  
532-06-00 W93-70040  
High-Performance Flight Research  
533-02-00 W93-70043  
Advanced Turboprop Systems  
535-03-00 W93-70044  
Advanced Turboprop Systems  
535-03-00 W93-70045  
Atmospheric Effects  
537-01-00 W93-70051  
Emissions and Source Noise  
537-02-00 W93-70054

**AIRCRAFT PERFORMANCE**

Aerodynamics Research and Technology  
505-59-00 W93-70003  
Propulsion and Power  
505-62-00 W93-70005  
Materials and Structures Research and Technology  
505-63-00 W93-70006  
Flight Systems Research and Technology  
505-68-00 W93-70015

**AIRCRAFT PILOTS**

Aging Aircraft  
538-02-00 W93-70061

**AIRCRAFT STRUCTURES**

Materials and Structures Research and Technology  
505-63-00 W93-70006  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
Materials and Structures Research and Technology  
505-63-00 W93-70009  
Hypersonic Training and Research  
505-70-00 W93-70021  
Advanced Composite Materials Technology  
510-02-00 W93-70037  
Advanced Composite Materials Technology  
510-02-00 W93-70038  
Aging Aircraft  
538-02-00 W93-70061

**AIRFRAME MATERIALS**

Materials and Structures Research and Technology  
505-63-00 W93-70007

**AIRFRAMES**

Materials and Structures Research and Technology  
505-63-00 W93-70007  
Aging Aircraft  
538-02-00 W93-70061

**AIRLINE OPERATIONS**

Materials and Structures Research and Technology  
505-63-00 W93-70009  
Atmospheric Effects  
537-01-00 W93-70049  
Aging Aircraft  
538-02-00 W93-70061

**AIRPORT TOWERS**

Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012

**AIRPORTS**

Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012  
Community Noise and Sonic Boom  
537-03-00 W93-70057

**ALASKA**

Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360  
ASF SAR Interferometry  
665-35-01 W93-70500

**ALBEDO**

Heterogeneous Scene Models  
462-61-03 W93-70347  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425  
Subgrid Variation of Surface Parameters  
578-42-15 W93-70444  
Neptune Data Analysis Program  
889-59-00 W93-70526

**ALGAE**

Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254  
Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356

**ALGORITHMS**

Materials and Structures Research and Technology  
505-63-00 W93-70006

Computational Aerodynamics  
509-10-00 W93-70029  
Computational Aerodynamics  
509-10-00 W93-70030  
Earth and Space Sciences  
509-20-00 W93-70034  
Hypersonics Research and Technology  
506-73-00 W93-70100

Space Data Systems  
586-03-00 W93-70136  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Ocean Color Data System  
428-82-06 W93-70272  
4D Data Assimilation for EOS  
429-81-04 W93-70275  
Global Assessment of Active Volcanism  
429-81-97 W93-70288  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289  
Validations of Passive Microwave Snow Water Equivalent Algorithm  
461-13-00 W93-70319  
Scatterometer Studies  
461-31-13 W93-70324  
Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Polarimetric Data Analysis  
461-64-11 W93-70334  
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Heterogeneous Scene Models  
462-61-03 W93-70347  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Soil Moisture from SAR  
462-62-05 W93-70349  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Thermal Infrared Science Support  
462-75-74 W93-70352  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
Two-Dimensional Stratospheric Chemical Model - Radiation  
579-23-01 W93-70451  
Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470  
Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
579-42-13 W93-70471  
Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498  
Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501  
Neptune Data Analysis Program  
889-59-00 W93-70526  
Flight Dynamics Technology  
310-10-26 W93-70528  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534  
Network Signal Processing  
310-30-70 W93-70543

**ALLOYS**

Metals and Alloys  
674-25-05 W93-70513  
Metals and Alloys  
674-25-08 W93-70514

**ALLUVIUM**

GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391

**ALTIMETERS**

Altitude Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325  
Retracking of Topex Waveform Data  
461-34-01 W93-70326

- Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328  
Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Radar-Altimeter Ice Data System  
578-97-20 W93-70448
- ALTIMETRY**  
U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172  
Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Topography from SEASAT and GEOSAT Overland Altimetry  
579-42-03 W93-70469
- ALTITUDE**  
Microwave Temperature Profiler  
464-14-20 W93-70374
- ALUMINUM ALLOYS**  
Earth-to-Orbit Transportation  
584-03-00 W93-70120
- ALUMINUM GALLIUM ARSENIDES**  
Space Communications Research and Technology  
506-72-00 W93-70098
- AMAZON REGION (SOUTH AMERICA)**  
Foreign Visitor Support  
429-97-04 W93-70290  
Topography from SEASAT and GEOSAT Overland Altimetry  
579-42-03 W93-70469
- AMBIGUITY**  
North American Fiducial Network  
465-14-11 W93-70397
- AMMONIA**  
In-Space Experiments  
506-74-00 W93-70105
- AMORPHOUS MATERIALS**  
Laboratory Astrophysics  
188-44-57 W93-70203
- AMPLIFIERS**  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542
- ANALOG DATA**  
Global Assessment of Active Volcanism  
428-81-94 W93-70269
- ANALOG TO DIGITAL CONVERTERS**  
Network Signal Processing  
310-30-70 W93-70543
- ANALYSIS (MATHEMATICS)**  
Computational Aerosciences  
509-10-00 W93-70030  
Earth and Space Sciences  
509-20-00 W93-70034
- ANELASTICITY**  
Geopotential Temporal Variations  
465-17-02 W93-70400
- ANGLE OF ATTACK**  
Flight Systems Research and Technology  
505-68-00 W93-70015  
High-Performance Flight Research  
533-02-00 W93-70041  
High Performance Flight Research  
533-02-00 W93-70042
- ANGULAR MOMENTUM**  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303  
Rapid Earth Orientation Changes  
579-36-10 W93-70462
- ANGULAR RESOLUTION**  
Submillimeter Astronomy  
188-44-23 W93-70194  
Gamma-Ray Spectroscopy  
188-46-58 W93-70208
- ANIMALS**  
Space Radiation  
199-04-14 W93-70228
- ANIMATION**  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488
- ANISOTROPY**  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196
- ANNEALING**  
A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains  
152-12-40 W93-70143
- ANNIHILATION REACTIONS**  
Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)  
188-46-01 W93-70204
- ANNUAL VARIATIONS**  
Mars 3-D Global Circulation Model  
154-95-80 W93-70161  
Global Hydrologic Cycle  
428-81-16 W93-70264  
Interannual Variability of Global Cycles  
429-81-06 W93-70276  
Global Hydrologic Cycle  
429-81-16 W93-70278  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321  
Satellite Radar for Forest Structure  
462-41-61 W93-70343  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
579-42-02 W93-70468  
Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
579-42-13 W93-70471  
Windows on Global Change  
665-82-03 W93-70503
- ANOMALIES**  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Problems in Interpreting Satellite Crustal Anomaly Field Data  
579-31-01 W93-70456
- ANTARCTIC REGIONS**  
Mars Data Analysis  
155-20-00 W93-70164  
Telepresence for Planetary Exploration  
186-06-01 W93-70182  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- ANTENNA ARRAYS**  
Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338  
Network Signal Processing  
310-30-70 W93-70543
- ANTENNA DESIGN**  
Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70011  
Space Communications Research and Technology  
506-72-00 W93-70096  
Advanced Space Systems for Users of NASA Networks  
310-20-46 W93-70537  
Antenna Systems Development  
310-20-65 W93-70539  
Radio Systems Development  
310-20-66 W93-70540  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542
- ANTENNA FEEDS**  
Advanced Transmitter Systems Development  
310-20-64 W93-70538
- ANTENNAS**  
Automation and Robotics  
586-02-00 W93-70129
- Airborne ESTAR  
461-38-01 W93-70327  
Goldstone DOSE Support  
465-28-02 W93-70403
- ANTHROPOMETRY**  
Information and Controls Research and Technology  
506-59-00 W93-70087
- APERTURES**  
Information and Controls Research and Technology  
506-59-00 W93-70089  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Astrometric Development Technology  
310-10-60 W93-70529
- APPLICATION SPECIFIC INTEGRATED CIRCUITS**  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406
- APPLICATIONS PROGRAMS (COMPUTERS)**  
Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Earth and Space Sciences  
509-20-00 W93-70035  
Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047  
NAS Operations  
536-02-00 W93-70048  
Automation and Robotics  
586-02-00 W93-70132  
Global Tectonic Motions  
465-14-01 W93-70394  
Networks Communication Technology  
310-20-38 W93-70536
- ARCHAEBACTERIA**  
The Early Evolution of Life  
199-52-32 W93-70248
- ARCHITECTURE (COMPUTERS)**  
Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70011  
Computational Aerosciences  
509-10-00 W93-70029  
Computational Aerosciences  
509-10-00 W93-70030  
Earth and Space Sciences  
509-20-00 W93-70034  
Information and Controls Research and Technology  
506-59-00 W93-70092  
Information and Communications  
586-03-00 W93-70137  
Data Interchange Standards  
656-61-03 W93-70479  
Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534  
Advanced Telemetry Processing Technology  
310-40-51 W93-70550  
DSN Data Processing and Productivity  
310-40-73 W93-70551
- ARCTIC OCEAN**  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- ARCTIC REGIONS**  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Microwave Temperature Profiler  
464-14-20 W93-70374  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384
- ARID LANDS**  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321  
Desert Mesoscale/PBL  
461-13-02 W93-70322  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
579-42-02 W93-70468
- ARIEL 5 SATELLITE**  
High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies  
188-46-01 W93-70205
- ARMED FORCES (UNITED STATES)**  
Propulsion Research and Technology  
506-42-00 W93-70069
- ARMOR**  
Materials and Structures Research and Technology  
506-43-00 W93-70077

**ARSENIC**

Science Sensing (Remote) W93-70109

**ARTIFICIAL INTELLIGENCE**

Information and Controls Research and Technology W93-70087  
 506-59-00 Information and Controls Research and Technology W93-70088  
 506-59-00 Information and Controls Research and Technology W93-70091  
 506-59-00 Automation and Robotics W93-70127  
 586-02-00 Automation and Robotics W93-70128  
 586-02-00 Automation and Robotics W93-70130  
 586-02-00 Automation and Robotics W93-70132  
 586-02-00 Automation and Robotics W93-70133  
 586-02-00 Information and Communications W93-70134  
 586-02-00 Construction of an Advanced Software Tool for Planetary Atmospheric Modeling W93-70494  
 656-65-24 Human-to-Machine Interface Technology W93-70545  
 310-40-37

**ARTIFICIAL SATELLITES**

Crustal Dynamics Data Information System (CDDIS) W93-70459  
 579-32-06 Topography from SEASAT and GEOSAT Overland Altimetry W93-70469  
 579-42-03

**ASHES**

Validation of Volcanic Plume Models with Remote Sensing W93-70413  
 465-44-04

**ASPHERICITY**

Geopotential Temporal Variations W93-70400  
 465-17-02 Geomagnetic Modeling of Core Fluid Motions W93-70458  
 579-31-07

**ASSIMILATION**

A 4D Data Assimilation for EOS Computer Support W93-70262  
 428-81-04 EOS IDS, Stratospheric Temperature and Trace Gas Trends W93-70280  
 429-81-36

**ASSOCIATION REACTIONS**

Laboratory Astrophysics W93-70201  
 188-44-57

**ASTEROID BELTS**

Observations of the Moon, Mercury, and Primitive Asteroids W93-70217  
 196-41-03

**ASTEROIDS**

Planetology W93-70139  
 151-01-70 Planetary Materials: Mineralogy and Petrology W93-70141  
 152-11-40 Planetary Materials: Experimental Petrology W93-70142  
 152-12-40 Planetary Materials: Chemistry W93-70144  
 152-13-40 Planetary Instrument Definition and Development W93-70169  
 157-03-50 Observations of the Moon, Mercury, and Primitive Asteroids W93-70217  
 196-41-03 Volatiles in the Solar System W93-70221  
 196-41-67 Impact Catastrophism on the Terrestrial Planets W93-70222  
 196-88-01 Characteristics of Volatiles in Interplanetary Dust Particles W93-70245  
 199-52-11 Solar System Exploration W93-70249  
 199-52-52

**ASTROMETRY**

Astrometric Imaging Telescope W93-70171  
 157-03-70 Optical Interferometry in Space W93-70213  
 188-78-41 HIPPARCOS VLBI W93-70256  
 399-18-00 Astrometric Development Technology W93-70529  
 310-10-60

**ASTRONAUT PERFORMANCE**

Behavior and Performance Research W93-70230  
 199-06-11

**ASTRONAUT TRAINING**

Behavior and Performance Research W93-70230  
 199-06-11

**ASTRONAUTS**

Longitudinal Studies (Medical Operations Longitudinal Studies) W93-70224  
 199-02-31 Space Radiation Effects and Protection (Environmental Health) W93-70225  
 199-04-00 Radiation Health W93-70226  
 199-04-11 Bone Mineral Metabolism and Muscle Physiology W93-70236  
 199-26-11

**ASTRONOMICAL CATALOGS**

Imaging Studies of Comets W93-70219  
 196-41-52

**ASTRONOMICAL MODELS**

Solar System Studies W93-70138  
 151-01-60 Planetary Materials: Mineralogy and Petrology W93-70141  
 152-11-40 Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs W93-70145  
 152-13-60

**ASTRONOMICAL OBSERVATORIES**

Science Sensing (Remote) W93-70111  
 582-03-00 Observatory Systems W93-70114  
 582-04-00 Observatory Systems W93-70115  
 582-04-00 Optical Technology for Space Astronomy W93-70186  
 188-41-23 UV Astronomy and Data Systems W93-70189  
 188-41-51 Optical Interferometry in Space W93-70213  
 188-78-41 Imaging Studies of Comets W93-70219  
 196-41-52

**ASTRONOMICAL PHOTOGRAPHY**

Imaging Studies of Comets W93-70219  
 196-41-52

**ASTRONOMICAL SPECTROSCOPY**

Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals W93-70159  
 154-75-80 Advanced Infrared Astronomy W93-70220  
 196-41-54 Volatiles in the Solar System W93-70221  
 196-41-67

**ASTRONOMY**

Science Sensing (Remote) W93-70109  
 582-03-00 Relativity, Cosmology, and Gravitational Radiation W93-70185  
 188-41-22 UV Astronomy and Data Systems W93-70189  
 188-41-51 Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals W93-70190  
 188-41-57 Research Computing Facility and Cataloging for Infrared W93-70192  
 188-44-01 Submillimeter Astronomy W93-70194  
 188-44-23 Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument W93-70195  
 188-44-23 Properties of Interstellar PAH's W93-70202  
 188-44-57 IR Astronomy ATD/Cryo Optical Testing and Science Support Activities W93-70214  
 188-78-44 Volatiles in the Solar System W93-70221  
 196-41-67 NASA/IPAC Extragalactic Database W93-70259  
 399-20-00 The Development of a Mid-Infrared Spectrometer for the Infrared Telescope in Space W93-70300  
 440-63-44

**ASTROPHYSICS**

Materials and Structures Research and Technology W93-70075  
 506-43-00 Systems Analysis W93-70085  
 506-49-00 Information and Controls Research and Technology W93-70090  
 506-59-00 In-Space Technology Experiments W93-70106  
 506-74-00 Science Sensing (Remote) W93-70109  
 582-03-00 Science Sensing (Remote) W93-70111  
 582-03-00 Science Sensing (Remote) W93-70112  
 582-03-00 Microgravity Nucleation and Particle Coagulation W93-70148  
 152-20-01

Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals W93-70190  
 188-41-57

Optical/UV Laboratory Astrophysics W93-70191  
 188-41-57 Research Computing Facility and Cataloging for Infrared W93-70192  
 188-44-01 Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument W93-70195  
 188-44-23 Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar W93-70197  
 188-44-24 Simulations of Compact Radio Sources W93-70198  
 188-44-53 Theory and Modeling: Infrared, Submillimeter, and Radio W93-70200  
 188-44-53 Laboratory Astrophysics W93-70201  
 188-44-57 Properties of Interstellar PAH's W93-70202  
 188-44-57 Laboratory Astrophysics W93-70203  
 188-44-57 High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies W93-70205  
 188-46-01 Gamma Ray Astronomy W93-70207  
 188-46-57 Optical Interferometry in Space W93-70213  
 188-78-41 Astrotech 21 W93-70215  
 188-78-44 Cosmic Evolution of Biogenic Compounds W93-70246  
 199-52-12 IPAC Astrophysics Data System (ADS) Support W93-70258  
 399-20-00 Space Physics Theory Program W93-70291  
 431-06-00 Interdisciplinary ATD Studies W93-70295  
 433-04-00 Space Physics Program Support/Detailees W93-70297  
 433-90-00 High Energy Astrophysics International Programs W93-70299  
 440-62-59 Two-Phase Nebulae W93-70304  
 452-22-93 NSSDC Astrophysics Data Systems Support W93-70484  
 656-61-17 SPARTAN 201 White Light Coronagraph W93-70521  
 879-10-00

**ASYMMETRY**

Integrative Biology W93-70241  
 199-40-32

**ATMOSPHERIC BOUNDARY LAYER**

Project to Interface Modeling W93-70283  
 429-81-72 IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface W93-70284  
 429-81-80 Subgrid Variation of Surface Parameters W93-70444  
 578-42-15 Earth Rotation and Mantle Structure W93-70460  
 579-36-03 Biogeochemistry and Geophysics Modeling and Data Analysis W93-70467  
 579-42-01

**ATMOSPHERIC CHEMISTRY**

Atmospheric Effects W93-70049  
 537-01-00 Human Support Research and Technology W93-70093  
 506-71-00 Spectral and Physical Properties of Planetary Atmospheric Constituents W93-70156  
 154-50-80 Planetary Aeronomy: Theory and Analysis W93-70157  
 154-60-80 Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals W93-70159  
 154-75-80 Planetary Lightning and Analysis of Voyager Observations W93-70160  
 154-90-80 EOS Science W93-70281  
 429-81-38 Project to Interface Modeling W93-70283  
 429-81-72 Oceanic Remote Sensing Library W93-70335  
 461-66-16 Heterogeneous Scene Models W93-70347  
 462-61-03 Ozone Measurements W93-70365  
 464-11-05 Airborne IR Spectrometry W93-70367  
 464-12-00

- Stratospheric Processes and Atmospheric Chemistry Studies  
464-14-00 W93-70373
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- Homogeneous and Heterogeneous Processes of Atmospheric Interest  
464-21-05 W93-70377
- Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378
- Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383
- Data Survey and Evaluation  
464-41-04 W93-70385
- Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386
- Measurement of Volcanic Gases  
465-44-05 W93-70414
- Climate Modeling with Emphasis on Aerosols and Clouds  
578-11-01 W93-70422
- Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429
- Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450
- Two-Dimensional Stratospheric Chemical Model - Radiation  
579-23-01 W93-70451
- Simulation of Tropospheric Ozone  
579-24-00 W93-70453
- Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472
- ATMOSPHERIC CIRCULATION**
- Science Sensing (Remote)  
582-03-00 W93-70110
- Science Sensing (Remote)  
582-03-00 W93-70113
- Dynamics of Planetary Atmospheres  
154-20-80 W93-70153
- Dynamical Properties of Planetary Atmospheres  
154-20-80 W93-70154
- Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157
- Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158
- Mars 3-D Global Circulation Model  
154-95-80 W93-70161
- Biosphere Atmospheric Interactions  
428-81-26 W93-70265
- Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267
- 4D Data Assimilation for EOS  
429-81-04 W93-70275
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- CO<sub>2</sub> Lidar Backscatter Experiment  
460-21-00 W93-70309
- Airborne Doppler Lidar  
460-21-52 W93-70311
- Atmospheric Backscatter Experiment  
460-22-53 W93-70313
- Wind Measurement Assessment  
460-28-41 W93-70314
- Stratospheric Processes and Atmospheric Chemistry Studies  
464-14-00 W93-70373
- Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384
- Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption  
465-44-06 W93-70415
- Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis  
578-10-00 W93-70421
- An Ocean General Circulation Model for Climate Studies  
578-41-43 W93-70443
- Modeling and Data Analysis, Climate and Hydrology Cryosphere Studies  
578-90-00 W93-70445
- Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452
- Rapid Earth Orientation Changes  
579-36-10 W93-70462
- ATMOSPHERIC COMPOSITION**
- Atmospheric Effects  
537-01-00 W93-70049
- Science Sensing (Remote)  
582-03-00 W93-70110
- Dynamics of Planetary Atmospheres  
154-20-80 W93-70153
- Spectral and Physical Properties of Planetary Atmospheric Constituents  
154-50-80 W93-70156
- Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217
- EOS IDS, EOSDIS Money  
428-81-36 W93-70266
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface  
428-81-80 W93-70268
- EOS IDS, Stratospheric Temperature and Trace Gas Trends  
429-81-36 W93-70280
- IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- Global Assessment of Active Volcanism  
429-81-96 W93-70287
- Global Assessment of Active Volcanism  
429-81-97 W93-70288
- Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289
- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361
- Laser Diode Sensor  
464-11-07 W93-70366
- Airborne IR Spectrometry  
464-12-00 W93-70367
- IR Solar Absorption Spectra  
464-12-05 W93-70368
- MM and Sub-MM Radiometry  
464-12-06 W93-70369
- NDSC Differential Absorption Lidar  
464-13-15 W93-70371
- NDSC Microwave Instrument Support  
464-13-22 W93-70372
- Stratospheric Processes and Atmospheric Chemistry Studies  
464-14-00 W93-70373
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere  
464-23-00 W93-70380
- Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements  
464-23-08 W93-70381
- Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383
- Global Tropospheric Experiment Aircraft, Measurements  
464-54-00 W93-70387
- Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416
- Two-Dimensional Stratospheric Chemical Model - Radiation  
579-23-01 W93-70451
- Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452
- Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- Climatological Stratospheric Modeling  
579-24-09 W93-70455
- Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472
- ATMOSPHERIC EFFECTS**
- Atmospheric Effects  
537-01-00 W93-70049
- Atmospheric Effects  
537-01-00 W93-70050
- Atmospheric Effects  
537-01-00 W93-70051
- Atmospheric Effects  
537-01-00 W93-70052
- Optical Technology for Space Astronomy  
188-41-23 W93-70186
- Global Assessment of Active Volcanism  
429-81-95 W93-70286
- Land Surface Climatology: HAPEX  
462-32-00 W93-70340
- Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348
- ATMOSPHERIC ELECTRICITY**
- Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160
- ATMOSPHERIC GENERAL CIRCULATION MODELS**
- Planetary Data System  
155-20-00 W93-70165
- Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
428-81-10 W93-70263
- Biosphere Atmospheric Interactions  
428-81-26 W93-70265
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface  
428-81-80 W93-70268
- Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- Desert Mesoscale/PBL  
461-13-02 W93-70322
- Extension and Testing of the Hydrologic Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423
- Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- Climate Stability: The Role of the Hydrological Cycle and the Thermohaline Circulation  
578-31-14 W93-70436
- An Ocean General Circulation Model for Climate Studies  
578-41-43 W93-70443
- Subgrid Variation of Surface Parameters  
578-42-15 W93-70444
- Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- Rapid Earth Orientation Changes  
579-36-10 W93-70462
- Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
579-42-13 W93-70471
- ATMOSPHERIC HEATING**
- Measurement of Volcanic Gases  
465-44-05 W93-70414
- Two-Dimensional Stratospheric Chemical Model - Radiation  
579-23-01 W93-70451
- Windows on Global Change  
665-82-03 W93-70503
- ATMOSPHERIC MODELS**
- Atmospheric Effects  
537-01-00 W93-70052
- Planetary Atmospheric Composition, Structure, and History  
154-10-80 W93-70152
- Dynamics of Planetary Atmospheres  
154-20-80 W93-70153
- Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157
- Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158
- Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160
- Mars 3-D Global Circulation Model  
154-95-80 W93-70161
- Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267
- Interannual Variability of Global Cycles  
429-81-06 W93-70276
- Global Hydrologic Cycle  
429-81-16 W93-70278
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- Project to Interface Modeling  
429-81-72 W93-70283
- IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316
- Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359
- IR Solar Absorption Spectra  
464-12-05 W93-70368
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- Data Survey and Evaluation  
464-41-04 W93-70385
- Parkfield GPS Experiment  
465-13-08 W93-70393
- GPS/VLBI Vertical Measurement  
465-14-09 W93-70396
- Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411
- Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption  
465-44-06 W93-70415

Climate Modeling with Emphasis on Aerosols and Clouds  
 578-11-01 W93-70422  
 Experimental Cloud Analysis Techniques  
 578-12-01 W93-70424  
 Remote Sensing of Air-Sea Fluxes  
 578-12-19 W93-70426  
 Outgoing Spectral Radiance: A Climate Diagnostic  
 578-12-59 W93-70429  
 Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
 578-40-00 W93-70441  
 Global Climate Modeling  
 578-41-01 W93-70442  
 Modeling and Data Analysis, Climate and Hydrology  
 Cryosphere Studies  
 578-90-00 W93-70445  
 Theoretical Investigation of Stratospheric Particulates  
 579-22-00 W93-70450  
 Two-Dimensional Stratospheric Chemical Model - Radiation  
 579-23-01 W93-70451  
 Stratospheric Chemical Model: Dynamics  
 579-23-10 W93-70452  
 Simulation of Tropospheric Ozone  
 579-24-00 W93-70453  
 Climatological Stratospheric Modeling  
 579-24-09 W93-70455  
 Biogeochemistry and Geophysics Modeling and Data Analysis  
 579-42-01 W93-70467  
 Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
 579-43-00 W93-70472  
 Construction of an Advanced Software Tool for Planetary Atmospheric Modeling  
 656-65-24 W93-70494  
 Concurrent Processing Testbed - Science Analysis  
 656-74-03 W93-70498  
 Optical Communications Technology Development  
 310-20-67 W93-70541

**ATMOSPHERIC MOISTURE**  
 Studies of Cloud Processes on the Outer Planets  
 154-60-80 W93-70158  
 Global Hydrologic Cycle  
 429-81-16 W93-70278  
 IR Remote Sensing of SST  
 460-21-28 W93-70310  
 NDSC Microwave Instrument Support  
 464-13-22 W93-70372  
 Global Climate Modeling  
 578-41-01 W93-70442

**ATMOSPHERIC OPTICS**  
 Infrared, Submillimeter, and Radio Astronomy  
 188-44-23 W93-70196

**ATMOSPHERIC PHYSICS**  
 Systems Analysis  
 506-49-00 W93-70085  
 Science Sensing (Remote)  
 582-03-00 W93-70110  
 Planetary Atmospheric Composition, Structure, and History  
 154-10-80 W93-70152  
 Planetary Aeronomy: Theory and Analysis  
 154-60-80 W93-70157  
 EOS Science  
 429-81-38 W93-70281  
 Project to Interface Modeling  
 429-81-72 W93-70283  
 Space Physics Theory Program  
 431-06-00 W93-70291  
 Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
 432-20-00 W93-70292  
 Interdisciplinary ATD Studies  
 433-04-00 W93-70295  
 Space Physics Program Support/Detailees  
 433-90-00 W93-70297  
 Multidimensional Studies of Tropospheric Clouds  
 460-47-00 W93-70316  
 Oceanic Remote Sensing Library  
 461-66-16 W93-70335  
 Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis  
 578-10-00 W93-70421  
 Outgoing Spectral Radiance: A Climate Diagnostic  
 578-12-59 W93-70429  
 Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
 578-40-00 W93-70441  
 Data System Integration (Commonality and Interoperability)  
 656-61-02 W93-70478  
 Space Physics Data System  
 656-61-18 W93-70485

Concurrent Processing Testbed - Science Analysis  
 656-74-03 W93-70498

**ATMOSPHERIC RADIATION**  
 Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
 428-81-10 W93-70263  
 Lower Stratosphere Aircraft Data Analysis  
 464-34-00 W93-70384  
 Experimental Cloud Analysis Techniques  
 578-12-01 W93-70424

**ATMOSPHERIC SCATTERING**  
 Two-Dimensional Stratospheric Chemical Model - Radiation  
 579-23-01 W93-70451  
 Neptune Data Analysis  
 889-59-00 W93-70525

**ATMOSPHERIC SOUNDING**  
 Science Sensing (Remote)  
 582-03-00 W93-70113  
 Global Assessment of Active Volcanism  
 429-81-96 W93-70287  
 Studies of Volcanic SO<sub>2</sub>, Theory  
 429-81-99 W93-70289  
 CO<sub>2</sub> Lidar Backscatter Experiment  
 460-21-00 W93-70309  
 Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements  
 464-23-08 W93-70381  
 Global Tropospheric Experiment Aircraft, Measurements  
 464-54-00 W93-70387  
 Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis  
 578-10-00 W93-70421  
 Atmospheric Parameter Mapping  
 578-12-21 W93-70428  
 Outgoing Spectral Radiance: A Climate Diagnostic  
 578-12-59 W93-70429  
 Sounding Rocket Experiments  
 879-11-38 W93-70522

**ATMOSPHERIC TEMPERATURE**  
 Planetary Atmospheric Composition, Structure, and History  
 154-10-80 W93-70152  
 Properties of Interstellar PAH's  
 188-44-57 W93-70202  
 EOS IDS, Stratospheric Temperature and Trace Gas Trends  
 429-81-36 W93-70280  
 Global Assessment of Active Volcanism  
 429-81-97 W93-70288  
 Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption  
 465-44-06 W93-70415  
 Meteorological Parameters Extraction  
 578-12-20 W93-70427  
 Earth Rotation and Mantle Structure  
 579-36-03 W93-70460  
 Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
 579-42-13 W93-70471

**ATMOSPHERIC WINDOWS**  
 Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument  
 188-44-23 W93-70195  
 IR Remote Sensing of SST  
 460-21-28 W93-70310

**ATOMIC BEAMS**  
 Materials and Structures Research and Technology  
 506-43-00 W93-70077  
 Band Structure Engineering on Silicon CCDs for Enhanced UV Response  
 188-41-24 W93-70188

**ATOMIC COLLISIONS**  
 Theory, Laboratory and Data Analysis for Solar Physics  
 170-38-53 W93-70180

**ATOMIC INTERACTIONS**  
 Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals  
 154-75-80 W93-70159

**ATROPHY**  
 Bone Mineral Metabolism and Muscle Physiology  
 199-26-11 W93-70236  
 Musculoskeletal (Biomedical)  
 199-26-12 W93-70237  
 Musculoskeletal  
 199-26-14 W93-70238

**ATTACK AIRCRAFT**  
 Systems Analysis  
 505-69-00 W93-70019

**ATTITUDE (INCLINATION)**  
 Information and Controls Research and Technology  
 506-59-00 W93-70091  
 Flight Dynamics Technology  
 310-10-26 W93-70528

**AUDIO EQUIPMENT**  
 Oceanic Remote Sensing Library  
 461-66-16 W93-70335

**AUDITORY PERCEPTION**  
 Behavior, Performance and Human Factors  
 199-06-12 W93-70231

**AUGMENTATION**  
 Data System Integration (Commonality and Interoperability)  
 656-61-02 W93-70478

**AURORAL ZONES**  
 Sounding Rockets: Space Plasma Physics Experiments  
 435-11-00 W93-70298

**AURORAS**  
 Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions  
 432-48-00 W93-70294

**AUSTRALIA**  
 Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
 461-13-01 W93-70321  
 Global Tectonic Motions  
 465-14-01 W93-70394  
 Carbon Mass Balance During Soil Evolution Along Climate Gradients  
 465-45-01 W93-70416  
 Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
 579-42-02 W93-70468

**AUTOMATIC CONTROL**  
 Information and Controls Research and Technology  
 506-59-00 W93-70087  
 Information and Controls Research and Technology  
 506-59-00 W93-70090  
 Information and Communications  
 586-02-00 W93-70134  
 Mission Operations Technology  
 310-40-45 W93-70546

**AUTOMATIC FREQUENCY CONTROL**  
 Network Signal Processing  
 310-30-70 W93-70543

**AUTOMATION**  
 Automation and Robotics  
 586-02-00 W93-70131

**AUTONOMIC NERVOUS SYSTEM**  
 Cardiopulmonary Physiology  
 199-14-12 W93-70233

**AUTONOMOUS SPACECRAFT CLOCKS**  
 GPS-Based DSN Calibration System  
 310-10-61 W93-70530

**AVANCE DIODES**  
 Space Communications Research and Technology  
 506-72-00 W93-70098

**AVIONICS**  
 Systems Analysis  
 505-69-00 W93-70017  
 Systems Analysis  
 505-69-00 W93-70019

**B**

**BACKGROUND RADIATION**  
 In-Space Technology Experiments  
 506-74-00 W93-70106  
 Infrared, Submillimeter, and Radio Astronomy  
 188-44-23 W93-70196

**BACKSCATTERING**  
 Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)  
 157-03-90 W93-70173  
 CO<sub>2</sub> Lidar Backscatter Experiment  
 460-21-00 W93-70309  
 Airborne Doppler Lidar  
 460-21-52 W93-70311  
 Lidar Target Calibration Facility  
 460-22-52 W93-70312  
 Atmospheric Backscatter Experiment  
 460-22-53 W93-70313  
 Wind Measurement Assessment  
 460-28-41 W93-70314  
 Scatterometer Research  
 461-31-09 W93-70323  
 Scatterometer Studies  
 461-31-13 W93-70324  
 Ice Sheet Geophysical Investigations Using Imaging Radar  
 461-66-18 W93-70336  
 Satellite Radar for Forest Structure  
 462-41-61 W93-70343  
 Radar Scattering Inversion: Forested Areas  
 462-62-04 W93-70348



- Soil Moisture from SAR  
462-62-05 W93-70349
- Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466
- Geographical Information System for Fusion and  
Analysis of High-Resolution Remote Sensing and Ground  
Truth Data  
656-65-22 W93-70493
- BACTERIA**  
ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499
- BALLOON FLIGHT**  
Mars 94 Winds  
155-20-04 W93-70168
- Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523
- BALLOON SOUNDING**  
Submillimeter Astronomy  
188-44-23 W93-70194
- MM and Sub-MM Radiometry  
464-12-06 W93-70369
- Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- BALLOON-BORNE INSTRUMENTS**  
Mars Data Analysis  
155-20-00 W93-70164
- Mars 94 Winds  
155-20-04 W93-70168
- Planetary Instrument Definition and Development  
157-03-50 W93-70169
- Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196
- Ozone Measurements  
464-11-05 W93-70365
- Laser Diode Sensor  
464-11-07 W93-70366
- Airborne IR Spectrometry  
464-12-00 W93-70367
- MM and Sub-MM Radiometry  
464-12-06 W93-70369
- Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370
- Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- Laser Laboratory Spectroscopy  
464-23-09 W93-70382
- Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523
- BALLOONS**  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166
- Ground-Based Support of Solar Physics  
170-38-52 W93-70179
- Submillimeter Astronomy  
188-44-23 W93-70194
- Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196
- BANDWIDTH**  
Space Communications Research and Technology  
506-72-00 W93-70098
- Automation and Robotics  
586-02-00 W93-70130
- Space Data Systems  
586-03-00 W93-70136
- Communications and Telemetry  
310-20-37 W93-70535
- Radio Systems Development  
310-20-66 W93-70540
- Network Signal Processing  
310-30-70 W93-70543
- Communication Systems Research  
310-30-71 W93-70544
- BAROCLINIC INSTABILITY**  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Modeling  
578-40-00 W93-70441
- BEACONS**  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504
- BEAM WAVEGUIDES**  
Advanced Transmitter Systems Development  
310-20-64 W93-70538
- Antenna Systems Development  
310-20-65 W93-70539
- Radio Systems Development  
310-20-66 W93-70540
- DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542
- BEAMS (RADIATION)**  
Space Communications Research and Technology  
506-72-00 W93-70099
- Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523
- BED REST**  
Cardiopulmonary Physiology  
199-14-12 W93-70233
- Regulatory Physiology (Biomedical)  
199-18-12 W93-70235
- Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- Musculoskeletal  
199-26-14 W93-70238
- BERING SEA**  
Polarimetric Data Analysis  
461-64-11 W93-70334
- BIAS**  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431
- BIBLIOGRAPHIES**  
UV Astronomy and Data Systems  
188-41-51 W93-70189
- Bibliography for Land Processes Publications  
579-82-00 W93-70473
- BIDIRECTIONAL REFLECTANCE**  
Heterogeneous Scene Models  
462-61-03 W93-70347
- BIOASTRONAUTICS**  
Clinical Medicine Technology Watch  
199-02-31 W93-70223
- Longitudinal Studies (Medical Operations Longitudinal  
Studies)  
199-02-31 W93-70224
- Environmental Health  
199-04-11 W93-70227
- Neuroscience (Biomedical)  
199-16-12 W93-70234
- Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- Musculoskeletal  
199-26-14 W93-70238
- BIOCHEMISTRY**  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- The Early Evolution of Life  
199-52-32 W93-70248
- BIODYNAMICS**  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- BIOGEOCHEMISTRY**  
Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- The Early Evolution of Life  
199-52-32 W93-70248
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea  
Interface  
428-81-80 W93-70268
- IDS Science for WHOI/GSFC Eos Project:  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- Oceanic Remote Sensing Library  
461-66-16 W93-70335
- Biogeochemical Cycling Research on the Oregon  
Transect  
462-43-00 W93-70344
- Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345
- Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359
- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- Biogeochemical Research in Tropical Ecosystems:  
Mechanisms of Trace Gas Production  
463-61-00 W93-70361
- Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- Biogeochemistry and Geophysics Modeling and Data  
Analysis  
579-42-01 W93-70467
- BIOLOGICAL EFFECTS**  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222
- Radiation Health  
199-04-11 W93-70226
- BIOLOGICAL EVOLUTION**  
Cell and Development Biology  
199-40-21 W93-70239
- Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- Prebiotic Evolution  
199-52-22 W93-70247
- The Early Evolution of Life  
199-52-32 W93-70248
- Solar System Exploration  
199-52-52 W93-70249
- Advanced Programs Theoretical Biology  
199-55-19 W93-70252
- BIOMASS**  
Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254
- Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345
- Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348
- Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- Biospheric/Atmospheric Interactions  
463-67-00 W93-70362
- Simulation of Tropospheric Ozone  
579-24-00 W93-70453
- Spatial and Temporal Distribution of Biomass  
Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472
- Geographical Information System for Fusion and  
Analysis of High-Resolution Remote Sensing and Ground  
Truth Data  
656-65-22 W93-70493
- BIOMEDICAL DATA**  
Longitudinal Studies (Medical Operations Longitudinal  
Studies)  
199-02-31 W93-70224
- Biotechnology  
674-23-08 W93-70509
- BIOPHYSICS**  
Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470
- BIOPROCESSING**  
Biotechnology Research  
674-23-01 W93-70508
- Biotechnology  
674-23-08 W93-70509
- BIOSPHERE**  
Biosphere Atmospheric Interactions  
428-81-26 W93-70265
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- BIOTECHNOLOGY**  
Biotechnology Research  
674-23-01 W93-70508
- Biotechnology  
674-23-08 W93-70509
- BIT SYNCHRONIZATION**  
Space Communications Research and Technology  
506-72-00 W93-70098
- BOEING 747 AIRCRAFT**  
Stratospheric Observatory for Infrared Astronomy  
(SOFIA)  
188-78-60 W93-70216
- BOLOMETERS**  
Information and Controls Research and Technology  
506-59-00 W93-70090
- Science Sensing (Remote)  
582-03-00 W93-70109
- Planetary Instrument Development Program/Planetary  
Astronomy High Temperature Superconductor  
Bolometers  
157-05-50 W93-70175
- Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196
- BONDING**  
Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188
- BONE DEMINERALIZATION**  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- Musculoskeletal (Biomedical)  
199-26-12 W93-70237

## BONE MINERAL CONTENT

Structural Biosystems  
199-40-42 W93-70242

**BONE MINERAL CONTENT**  
Structural Biosystems  
199-40-42 W93-70242

**BONES**  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236  
Structural Biosystems  
199-40-42 W93-70242

**BOUNDARIES**  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140

**BOUNDARY CONDITIONS**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Project to Interface Modeling  
429-81-72 W93-70283  
Fluid Physics  
674-24-08 W93-70512

**BOUNDARY LAYER CONTROL**  
Community Noise and Sonic Boom  
537-03-00 W93-70056

**BOUNDARY LAYER TRANSITION**  
Aerodynamics Research and Technology  
505-59-00 W93-70003

**BOUNDARY LAYERS**  
GA/Commuter Engine Technology  
535-05-00 W93-70046  
Mars 3-D Global Circulation Model  
154-95-80 W93-70161  
Micro Weather Stations for Mars  
157-04-80 W93-70174  
IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Airborne Doppler Lidar  
460-21-52 W93-70311

**BRAYTON CYCLE**  
Earth-Orbiting Platforms  
585-03-00 W93-70124

**BRAZIL**  
Foreign Visitor Support  
429-97-04 W93-70290

**BREADBOARD MODELS**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Automation and Robotics  
586-02-00 W93-70128  
Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253  
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495

**BREMSSTRAHLUNG**  
Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)  
188-46-01 W93-70204

**BRIGHTNESS DISTRIBUTION**  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521

**BRIGHTNESS TEMPERATURE**  
Radiative Effects in Clouds First International Satellite Cloud Climatology Regional Experiment  
460-42-00 W93-70315  
Microwave Temperature Profiler  
464-14-20 W93-70374

**BRINES**  
Active/Passive Sea Ice Analysis  
578-32-24 W93-70437  
Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

**BROADBAND**  
Computational Aerosciences  
509-10-00 W93-70029  
Band Structure Engineering on Silicon CCDs for Enhanced UV Response  
188-41-24 W93-70188  
High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies  
188-46-01 W93-70205  
Infrared Studies of Planetary Debris Around Young Main Sequence Stars  
452-11-93 W93-70301

**BROMINE COMPOUNDS**  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384

## BUBBLES

Glasses and Ceramics  
674-26-08 W93-70516

## BUOYANCY

Combustion Science  
674-22-05 W93-70507  
Metals and Alloys  
674-25-08 W93-70514

## BUOYS

Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325  
Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438

## C

## C BAND

Airborne Synthetic Aperture Radar (AIRSAR) Operations  
462-75-62 W93-70351  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420

## C-135 AIRCRAFT

General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232

## CALCIFICATION

Structural Biosystems  
199-40-42 W93-70242

## CALCIUM

Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236

## CALIBRATING

Mars Data Analysis  
155-20-00 W93-70164  
Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274  
Lidar Target Calibration Facility  
460-22-52 W93-70312  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Scatterometer Research  
461-31-09 W93-70323  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Polarimetric Data Analysis  
461-64-11 W93-70334  
Soil Moisture from SAR  
462-62-05 W93-70349  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
462-75-62 W93-70351  
Thermal Infrared Science Support  
462-75-74 W93-70352  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355  
AVIRIS Operations  
463-75-63 W93-70364  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
AVIRIS Operations  
465-65-01 W93-70417  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466  
Sounding Rocket Experiments  
879-11-38 W93-70522  
Proposal for a High-Energy Imaging Device (HEID) on a Balloon  
879-11-48 W93-70523  
GPS-Based DSN Calibration System  
310-10-61 W93-70530  
Space Systems and Navigation Technology  
310-10-63 W93-70532  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542

**CALIFORNIA**  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408  
Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416

## CALORIMETERS

Information and Controls Research and Technology  
506-59-00 W93-70090  
Science Sensing (Remote)  
582-03-00 W93-70111  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210

## CAMERAS

Materials and Structures Research and Technology  
506-43-00 W93-70075  
Mars 94 Winds  
155-20-04 W93-70168  
Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196

## CANADA

Biogeochemical Cycling Research on the Oregon Transect  
462-43-00 W93-70344  
Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360

## CANOPIES (VEGETATION)

Satellite Radar for Forest Structure  
462-41-61 W93-70343  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Visiting Scientists  
462-76-49 W93-70353  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504

## CANS

Space Flight Research and Technology  
506-48-00 W93-70078

## CAPILLARY FLOW

Fluid Physics  
674-24-05 W93-70511

## CAPILLARY WAVES

Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325

## CARBON

Properties of Interstellar PAH's  
188-44-57 W93-70202  
Characteristics of Volatiles in Interplanetary Dust Particles  
199-52-11 W93-70245  
Biogeochemical Cycling Research on the Oregon Transect  
462-43-00 W93-70344  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363

## CARBON CYCLE

Interannual Variability of Global Cycles  
429-81-06 W93-70276  
Foreign Visitor Support  
429-97-04 W93-70290  
Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356

## CARBON DIOXIDE

Mars Surface and Atmosphere Studies  
155-04-00 W93-70162  
Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362  
Laser Diode Sensor  
464-11-07 W93-70366

## CARBON DIOXIDE LASERS

CO<sub>2</sub> Lidar Backscatter Experiment  
460-21-00 W93-70309  
Lidar Target Calibration Facility  
460-22-52 W93-70312

- Atmospheric Backscatter Experiment  
460-22-53 W93-70313  
Wind Measurement Assessment  
460-28-41 W93-70314
- CARBON ISOTOPES**  
Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- CARBON MONOXIDE**  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
Simulation of Tropospheric Ozone  
579-24-00 W93-70453  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- CARBON-CARBON COMPOSITES**  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Materials and Structures Research and Technology  
506-43-00 W93-70074  
Solar Probe ATD  
433-06-00 W93-70296
- CARBONACEOUS CHONDRITES**  
Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217
- CARBONACEOUS METEORITES**  
Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs  
152-13-60 W93-70145
- CARCINOGENS**  
Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225
- CARDIOVASCULAR SYSTEM**  
Clinical Medicine Technology Watch  
199-02-31 W93-70223  
Cardiopulmonary Physiology  
199-14-12 W93-70233
- CARNOT CYCLE**  
Observatory Systems  
582-04-00 W93-70114
- CARTESIAN COORDINATES**  
Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395  
Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
- CASSINI MISSION**  
Imaging Spectropolarimeter  
157-03-70 W93-70170
- CATALOGS (PUBLICATIONS)**  
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383  
Science Digital Data Preservation  
656-61-07 W93-70482  
NSSDC Astrophysics Data Systems Support  
656-61-17 W93-70484
- CATALYSIS**  
Materials and Structures Research and Technology  
506-43-00 W93-70071
- CATASTROPHE THEORY**  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222
- CAVITIES**  
Frequency and Timing Research  
310-10-62 W93-70531
- CELESTIAL GEODESY**  
Theory of Geodetic Transformations  
465-15-06 W93-70398
- CELLS (BIOLOGY)**  
Cell and Development Biology  
199-40-21 W93-70239  
Cell and Developmental Biology  
199-40-22 W93-70240
- CENTRAL PROCESSING UNITS**  
Computational Aerosciences  
509-10-00 W93-70029
- CENTRIFUGAL FORCE**  
Neuroscience (Biomedical)  
199-16-12 W93-70234
- CENTRIFUGING**  
Cell and Developmental Biology  
199-40-22 W93-70240
- CERAMIC FIBERS**  
Glasses and Ceramics  
674-26-05 W93-70515
- CERAMIC MATRIX COMPOSITES**  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Enabling Propulsion Materials  
537-04-00 W93-70058  
Materials and Structures Research and Technology  
506-43-00 W93-70071
- CERAMICS**  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Glasses and Ceramics  
674-26-05 W93-70515  
Glasses and Ceramics  
674-26-08 W93-70516
- CERTIFICATION**  
Advanced Composite Materials Technology  
510-02-00 W93-70037  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060
- CHANNELS (DATA TRANSMISSION)**  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
462-75-62 W93-70351  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420
- CHAOS**  
Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292
- CHARACTERIZATION**  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Advanced Composite Materials Technology  
510-02-00 W93-70038
- CHARGE COUPLED DEVICES**  
Band Structure Engineering on Silicon CCDs for Enhanced UV Response  
188-41-24 W93-70188  
X-Ray Astronomy CCD  
188-46-59 W93-70209  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210  
Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217  
Imaging Studies of Comets  
196-41-52 W93-70219  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521
- CHECKOUT**  
UV Astronomy and Data Systems  
188-41-51 W93-70189
- CHEMICAL ANALYSIS**  
Science Sensing (Remote)  
582-03-00 W93-70109  
Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs  
152-13-60 W93-70145  
Solar System Exploration  
199-52-52 W93-70249
- CHEMICAL COMPOSITION**  
Propulsion Research and Technology  
506-42-00 W93-70068  
Human Support Research and Technology  
506-71-00 W93-70093  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials: Geochronology  
152-14-40 W93-70146  
Laboratory Astrophysics  
188-44-57 W93-70203  
Characteristics of Volatiles in Interplanetary Dust Particles  
199-52-11 W93-70245  
Prebiotic Evolution  
199-52-22 W93-70247  
The Early Evolution of Life  
199-52-32 W93-70248  
Solar System Exploration  
199-52-52 W93-70249  
Exobiology Intact Capture Technology Development  
199-52-54 W93-70250  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
The Nature of Interstellar Dust, Ices and Polycyclic Aromatic Hydrocarbons  
399-50-00 W93-70261  
CO<sub>2</sub> Lidar Backscatter Experiment  
460-21-00 W93-70309  
Airborne ESTAR  
461-38-01 W93-70327  
Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416
- CHEMICAL ELEMENTS**  
Science Sensing (Remote)  
582-03-00 W93-70109
- CHEMICAL ENERGY**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067
- CHEMICAL EVOLUTION**  
Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160  
Characteristics of Volatiles in Interplanetary Dust Particles  
199-52-11 W93-70245  
Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246  
Prebiotic Evolution  
199-52-22 W93-70247  
Exploration Exobiology  
199-52-82 W93-70251  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
Planet-Forming Disks  
452-21-93 W93-70302  
Chemical Evolution of Interstellar Ices: The Connection with Primitive Solar System Materials  
452-33-93 W93-70306
- CHEMICAL PROPERTIES**  
Properties of Interstellar PAH's  
188-44-57 W93-70202  
Prebiotic Evolution  
199-52-22 W93-70247
- CHEMICAL PROPULSION**  
System Analysis  
506-49-00 W93-70083
- CHEMICAL REACTIONS**  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Atmospheric Effects  
537-01-00 W93-70049  
Hypersonics Research and Technology  
506-73-00 W93-70100  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
Prebiotic Evolution  
199-52-22 W93-70247  
Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
Thermosphere-Ionosphere-Mesosphere-Magnetospheric Interactions  
432-48-00 W93-70294  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
Homogeneous and Heterogeneous Processes of Atmospheric Interest  
464-21-05 W93-70377
- CHEMISORPTION**  
Materials and Structures Research and Technology  
506-43-00 W93-70071
- CHIPS (ELECTRONICS)**  
Space Data Systems  
586-03-00 W93-70136
- CHLORINE COMPOUNDS**  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384
- CHLORINE OXIDES**  
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383
- CHLOROCARBONS**  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- CHLOROPHYLLS**  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- CHROMATOGRAPHY**  
Solar System Exploration  
199-52-52 W93-70249
- CHROMOSOMES**  
Space Radiation  
199-04-14 W93-70228
- CHROMOSPHERE**  
Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180
- CHRONOLOGY**  
Evolution of Volcanic Terrains  
465-44-02 W93-70412
- CHUKCHI SEA**  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Polarimetric Data Analysis  
461-64-11 W93-70334  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438
- CIRCADIAN RHYTHMS**  
Integrative Biology  
199-40-32 W93-70241

## CIRRUS CLOUDS

- Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424
- CIVIL AVIATION**  
Aerodynamics Research and Technology  
505-59-00 W93-70002  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Systems Analysis  
505-69-00 W93-70018  
Systems Analysis  
505-69-00 W93-70019  
Computational/Aeroscience  
509-10-00 W93-70031  
Atmospheric Effects  
537-01-00 W93-70049  
Aging Aircraft  
538-02-00 W93-70061

## CLASSIFICATIONS

- Materials and Structures Research and Technology  
506-43-00 W93-70077  
Desert Mesoscale/PBL  
461-13-02 W93-70322  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440

## CLEARANCES

- Materials and Structures Research and Technology  
505-63-00 W93-70006

## CLIMATE

- Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Desert Mesoscale/PBL  
461-13-02 W93-70322  
Biogeochemical Cycling Research on the Oregon  
Transect  
462-43-00 W93-70344  
Soil Moisture from SAR  
462-62-05 W93-70349  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Volcanic Cloud Dispersion, Chemistry and Microphysics:  
An Analysis of the El Chichon Eruption  
465-44-06 W93-70415  
Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Data Analysis  
578-10-00 W93-70421  
Climate Modeling with Emphasis on Aerosols and  
Clouds  
578-11-01 W93-70422  
Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
Meteorological Parameters Extraction  
578-12-20 W93-70427  
Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Modeling  
578-40-00 W93-70441  
Global Climate Modeling  
578-41-01 W93-70442  
An Ocean General Circulation Model for Climate  
Studies  
578-41-43 W93-70443  
Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445  
Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451  
Climatological Stratospheric Modeling  
579-24-09 W93-70455

- Landsat Land Cover Pathfinder  
579-98-00 W93-70476
- CLIMATE CHANGE**  
Atmospheric Effects  
537-01-00 W93-70049  
Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)  
428-81-10 W93-70263  
Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Role of Air-Sea Exchanges and Ocean Circulation  
(Science)  
428-81-10 W93-70277  
Global Hydrologic Cycle  
428-81-16 W93-70278  
EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280  
EOS Science  
429-81-38 W93-70281  
Project to Interface Modeling  
429-81-72 W93-70283  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289  
GEWEX Program Support  
461-50-03 W93-70331  
Oceanic Remote Sensing Library  
461-66-16 W93-70335  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358  
Paleocological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360  
Biogeochemical Research in Tropical Ecosystems:  
Mechanisms of Trace Gas Production  
463-61-00 W93-70361  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410  
Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416  
Large Scale Air-Sea Interactions  
578-22-26 W93-70433  
Climate Stability: The Role of the Hydrological Cycle  
and the Thermohaline Circulation  
578-31-14 W93-70436  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
Global Climate Modeling  
578-41-01 W93-70442  
Climatological Stratospheric Modeling  
579-24-09 W93-70455  
Soil/Canopy Moisture and Temperature Profiles Using  
Remote Sensing and Modeling  
579-42-13 W93-70471  
Landsat Land Cover Pathfinder  
579-98-00 W93-70476  
Windows on Global Change  
665-82-03 W93-70503
- CLIMATOLOGY**  
Atmospheric Effects  
537-01-00 W93-70052  
Mars 3-D Global Circulation Model  
154-95-80 W93-70161  
Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)  
428-81-10 W93-70263  
Global Hydrologic Cycle  
428-81-16 W93-70264  
EOS IDS, EOSDIS Money  
428-81-36 W93-70266  
Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274  
Global Hydrologic Cycle  
429-81-16 W93-70278  
EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280  
Project to Interface Modeling  
429-81-72 W93-70283  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316  
Desert Mesoscale/PBL  
461-13-02 W93-70322

- GEWEX Program Support  
461-50-03 W93-70331  
Land Surface Climatology: HAPEX  
462-32-00 W93-70340  
Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Measurement of Volcanic Gases  
465-44-05 W93-70414  
Volcanic Cloud Dispersion, Chemistry and Microphysics:  
An Analysis of the El Chichon Eruption  
465-44-06 W93-70415  
Climate Modeling with Emphasis on Aerosols and  
Clouds  
578-11-01 W93-70422  
Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425  
Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426  
Global Monthly Mean Ocean Variability  
578-22-29 W93-70435  
Climate Stability: The Role of the Hydrological Cycle  
and the Thermohaline Circulation  
578-31-14 W93-70436  
Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate  
578-35-02 W93-70439  
Global Climate Modeling  
578-41-01 W93-70442  
An Ocean General Circulation Model for Climate  
Studies  
578-41-43 W93-70443  
Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445  
Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451  
Climatological Stratospheric Modeling  
579-24-09 W93-70455  
Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470
- CLINICAL MEDICINE**  
Clinical Medicine Technology Watch  
199-02-31 W93-70223
- CLOCKS**  
In-Space Technology Experiments  
506-74-00 W93-70106
- CLOSED ECOLOGICAL SYSTEMS**  
Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253  
Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254
- CLOUD COVER**  
Planetary Atmospheric Composition, Structure, and  
History  
154-10-80 W93-70152  
Atmospheric Backscatter Experiment  
460-22-53 W93-70313  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316
- CLOUD HEIGHT INDICATORS**  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410
- CLOUD PHYSICS**  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316  
Climate Modeling with Emphasis on Aerosols and  
Clouds  
578-11-01 W93-70422  
Neptune Data Analysis  
889-59-00 W93-70524  
Neptune Data Analysis Program  
889-59-00 W93-70526
- CLOUDS**  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
EOS Science  
429-81-38 W93-70281

**CLOUDS (METEOROLOGY)**

- Role of Air-Sea Exchanges and Ocean Circulation (Computing) W93-70263
- 428-81-10
- Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project W93-70274
- 428-82-18
- Role of Air-Sea Exchanges and Ocean Circulation (Science) W93-70277
- 429-81-10
- EOS Science W93-70281
- 429-81-38
- Polar Exchange at the Sea Surface: JPL Component W93-70282
- 429-81-64
- Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption W93-70415
- 465-44-06
- An Integrated Study of Surface Property Variations W93-70425
- 578-12-02
- Remote Sensing of Air-Sea Fluxes W93-70426
- 578-12-19
- Meteorological Parameters Extraction W93-70427
- 578-12-20
- Global Climate Modeling W93-70442
- 578-41-01
- Theoretical Investigation of Stratospheric Particulates W93-70450
- 579-22-00

**CMOS**

- Information and Communications W93-70137
- 586-03-00

**COAGULATION**

- Microgravity Nucleation and Particle Coagulation Experiments W93-70148
- 152-20-01
- Two-Phase Nebulae W93-70304
- 452-22-93

**COASTAL WATER**

- Phytoplankton Dynamics of North Pacific Ocean W93-70356
- 463-11-09

**COASTAL ZONE COLOR SCANNER**

- Space Data Systems W93-70136
- 586-03-00
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface W93-70268
- 428-81-80
- IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface W93-70284
- 429-81-80
- Phytoplankton Dynamics of North Pacific Ocean W93-70356
- 463-11-09
- Bio-Optical Interpretation of Ocean Color Imagery W93-70357
- 463-11-62

**COASTS**

- Paleoecological Studies of CH<sub>4</sub> Emissions W93-70360
- 463-43-07
- Carbon Mass Balance During Soil Evolution Along Climate Gradients W93-70416
- 465-45-01

**COATINGS**

- Materials and Structures Research and Technology W93-70075
- 506-43-00
- Optical Technology for Space Astronomy W93-70186
- 188-41-23

**COCKPITS**

- Controls, Guidance and Human Factors Research and Technology W93-70011
- 505-64-00
- Flight Systems Research and Technology W93-70015
- 505-68-00

**CODING**

- Space Data Systems W93-70136
- 586-03-00
- Communications and Telemetry W93-70535
- 310-20-37
- Advanced Space Systems for Users of NASA Networks W93-70537
- 310-20-46
- Communication Systems Research W93-70544
- 310-30-71

**COEFFICIENTS**

- Laser Laboratory Spectroscopy W93-70382
- 464-23-09
- Modeling of the Main Magnetic Field W93-70457
- 579-31-02

**COLLAPSE**

- Planet-Forming Disks W93-70302
- 452-21-93

**COLLATING**

- Problems in Interpreting Satellite Crustal Anomaly Field Data W93-70456
- 579-31-01

**COLLECTION**

- Planetary Hardcopy Preservation Task W93-70486
- 656-61-20

**COLLIMATION**

- Simulations of Compact Radio Sources W93-70198
- 188-44-53

**COLLIMATORS**

- Proposal for a High-Energy Imaging Device (HEID) on a Balloon W93-70523
- 879-11-48

**COLLISION AVOIDANCE**

- Automation and Robotics W93-70130
- 586-02-00

**COLLISION PARAMETERS**

- Solar Physics Studies W93-70181
- 170-38-53

**COLLISIONS**

- Solar Physics Studies W93-70181
- 170-38-53
- Impact Catastrophism on the Terrestrial Planets W93-70222
- 196-88-01

**COLOR**

- Computer and Information Systems Support W93-70474
- 579-82-90
- Mission Operations Technology W93-70546
- 310-40-45

**COMBAT**

- Flight Systems Research and Technology W93-70015
- 505-68-00

**COMBUSTION**

- Combustion Science W93-70507
- 674-22-05

**COMBUSTION CHAMBERS**

- Emissions and Source Noise W93-70053
- 537-02-00
- Emissions and Source Noise W93-70054
- 537-02-00
- Earth-to-Orbit Transportation W93-70121
- 584-03-00

**COMBUSTION CHEMISTRY**

- Propulsion Research and Technology W93-70068
- 506-42-00
- Biogeochemical Research in Temperate Ecosystems W93-70345
- 462-43-00

**COMBUSTION PHYSICS**

- Propulsion Research and Technology W93-70068
- 506-42-00
- Earth-To-Orbit Transportation W93-70119
- 584-03-00
- Combustion Science W93-70507
- 674-22-05
- Ground Experiment Operations W93-70518
- 674-28-05

**COMBUSTION PRODUCTS**

- Emissions and Source Noise W93-70053
- 537-02-00
- Emissions and Source Noise W93-70054
- 537-02-00
- Biospheric/Atmospheric Interactions W93-70362
- 463-67-00
- Simulation of Tropospheric Ozone W93-70453
- 579-24-00
- Spatial and Temporal Distribution of Biomass W93-70472
- Combustion and Pyrogenic Trace Gas Emissions
- 579-43-00

**COMBUSTION STABILITY**

- Earth-To-Orbit Transportation W93-70119
- 584-03-00

**COMET NUCLEI**

- Solar System Studies W93-70138
- 151-01-60
- Advanced Infrared Astronomy W93-70220
- 196-41-54
- Volatiles in the Solar System W93-70221
- 196-41-67
- Two-Phase Nebulae W93-70304
- 452-22-93

**COMET TAILS**

- Imaging Studies of Comets W93-70219
- 196-41-52
- Magnetospheric Coupling W93-70293
- 432-36-00

**COMETARY ATMOSPHERES**

- Imaging Studies of Comets W93-70219
- 196-41-52

**COMETS**

- Space Communications Research and Technology W93-70099
- 506-72-00
- Planetology W93-70139
- 151-01-70
- Planetary Materials: Mineralogy and Petrology W93-70141
- 152-11-40
- Planetary Materials: Experimental Petrology W93-70142
- 152-12-40
- Planetary Materials: Chemistry W93-70144
- 152-13-40
- Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs W93-70145
- 152-13-60

- Spectral and Physical Properties of Planetary Atmospheric Constituents W93-70156
- 154-50-80
- Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals W93-70159
- 154-75-80
- Planetary Instrument Definition and Development W93-70169
- 157-03-50
- Imaging Studies of Comets W93-70219
- 196-41-52
- Advanced Infrared Astronomy W93-70220
- 196-41-54
- Volatiles in the Solar System W93-70221
- 196-41-67
- Characteristics of Volatiles in Interplanetary Dust Particles W93-70245
- 199-52-11
- Solar System Exploration W93-70249
- 199-52-52
- Magnetospheric Coupling W93-70293
- 432-36-00
- Origins of Solar Systems W93-70305
- 452-23-94
- Chemical Evolution of Interstellar Ices: The Connection with Primitive Solar System Materials W93-70306
- 452-33-93

**COMMERCIAL AIRCRAFT**

- Controls, Guidance and Human Factors Research and Technology W93-70011
- 505-64-00
- Advanced Turboprop Systems W93-70045
- 535-03-00
- Emissions and Source Noise W93-70055
- 537-02-00
- Aging Aircraft W93-70061
- 538-02-00

**COMMERCIAL SPACECRAFT**

- Space Communications Research and Technology W93-70096
- 506-72-00

**COMMUNICATION NETWORKS**

- Earth and Space Sciences W93-70032
- 509-20-00
- Space Communications Research and Technology W93-70098
- 506-72-00
- Telepresence for Planetary Exploration W93-70182
- 186-06-01
- Goldstone DOSE Support W93-70403
- 465-28-02
- Navigation Ancillary Information Facility (NAIF) W93-70480
- 656-61-05
- Space Systems and Navigation Technology W93-70532
- 310-10-63
- Optical Communications W93-70533
- 310-20-35
- Communications and Telemetry W93-70535
- 310-20-37
- Communication Systems Research W93-70544
- 310-30-71

**COMMUNICATION SATELLITES**

- Space Communications Research and Technology W93-70096
- 506-72-00
- In-Space Experiments W93-70105
- 506-74-00

**COMPARISON**

- High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies W93-70205
- 188-46-01

**COMPATIBILITY**

- Space Flight Research and Technology W93-70081
- 506-48-00

**COMPILERS**

- Data Interchange Standards W93-70479
- 656-61-03

**COMPONENT RELIABILITY**

- DSS 13 Instrumentation and Capabilities W93-70542
- 310-30-69

**COMPOSITE MATERIALS**

- Materials and Structures Research and Technology W93-70006
- 505-63-00
- Materials and Structures Research and Technology W93-70008
- 505-63-00
- Advanced Composite Materials Technology W93-70037
- 510-02-00
- Advanced Composite Materials Technology W93-70038
- 510-02-00

**COMPOSITE STRUCTURES**

- Materials and Structures Research and Technology W93-70007
- 505-63-00
- Advanced Composite Materials Technology W93-70037
- 510-02-00
- Advanced Composite Materials Technology W93-70038
- 510-02-00

**COMPRESSION WAVES**

- Lateral Variations in Solid Tides W93-70401
- 465-17-04

**COMPRESSORS**

Flight Systems Research and Technology  
505-68-00 W93-70014

**COMPTON EFFECT**

Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204

**COMPUTATION**

Computational Aerosciences  
509-10-00 W93-70028  
Earth and Space Sciences  
509-20-00 W93-70033  
Research Computing Facility and Cataloging for  
Infrared  
188-44-01 W93-70192  
A 4D Data Assimilation for EOS Computer Support  
428-81-04 W93-70262

**COMPUTATIONAL ASTROPHYSICS**

Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199

**COMPUTATIONAL CHEMISTRY**

Emissions and Source Noise  
537-02-00 W93-70053  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062  
Materials and Structures Research and Technology  
506-43-00 W93-70071

**COMPUTATIONAL FLUID DYNAMICS**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Hypersonic Research and Technology  
505-70-00 W93-70022  
Computational Aerosciences  
509-10-00 W93-70028  
Computational Aerosciences  
509-10-00 W93-70029  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
High Performance Flight Research  
533-02-00 W93-70042  
Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047  
NAS Operations  
536-02-00 W93-70048  
Emissions and Source Noise  
537-02-00 W93-70053  
Mars Surface and Atmosphere Studies  
155-04-00 W93-70162  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517

**COMPUTER AIDED DESIGN**

Hypersonic Research and Technology  
505-70-00 W93-70020  
Computational Aerosciences  
509-10-00 W93-70030  
Computational/Aeroscience  
509-10-00 W93-70031  
Systems Analysis  
506-49-00 W93-70084  
Hypersonics Research and Technology  
506-73-00 W93-70100

**COMPUTER COMPONENTS**

Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464

**COMPUTER DESIGN**

Computational Aerosciences  
509-10-00 W93-70029

**COMPUTER GRAPHICS**

LTP Computer Support  
579-41-04 W93-70465  
Computer and Information Systems Support  
579-82-90 W93-70474  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488  
Graphical Methods for Science Visualization and Data  
Analysis  
656-65-05 W93-70489  
Solar System Visualization (SSV): Scientific Tools for  
NASA/JPL Image Archives  
656-65-06 W93-70490  
Construction of an Advanced Software Tool for Planetary  
Atmospheric Modeling  
656-65-24 W93-70494  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498  
Windows on Global Change  
665-82-03 W93-70503  
Mission Operations Technology  
310-40-45 W93-70546

**COMPUTER INFORMATION SECURITY**

Earth and Space Sciences  
509-20-00 W93-70032

**COMPUTER NETWORKS**

Earth and Space Sciences  
509-20-00 W93-70032  
NAS Operations  
536-02-00 W93-70048  
Automation and Robotics  
586-02-00 W93-70128  
NASA/IPAC Extragalactic Database  
399-20-00 W93-70259  
A 4D Data Assimilation for EOS Computer Support  
428-81-04 W93-70262  
LTP Visualization  
578-97-53 W93-70449  
Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459  
LTP Computer Support  
579-41-04 W93-70465

**COMPUTER PROGRAMMING**

Computational/Aeroscience  
509-10-00 W93-70031  
Earth and Space Sciences  
509-20-00 W93-70034  
Earth and Space Sciences  
509-20-00 W93-70035  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Automation and Robotics  
586-02-00 W93-70129  
Automation and Robotics  
586-02-00 W93-70132  
LTP Computer Support  
579-41-04 W93-70465  
Data Interchange Standards  
656-61-03 W93-70479  
Center of Excellence for Space Data Information  
Sciences (CESDIS)  
656-65-07 W93-70491  
DataHub - Knowledge-Based Assistance for Science  
Visualization and Analysis Using Large Distributed  
Databases  
656-65-21 W93-70492  
Construction of an Advanced Software Tool for Planetary  
Atmospheric Modeling  
656-65-24 W93-70494  
Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495  
A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498  
Software Engineering Technology  
310-10-23 W93-70527  
GPS-Based DSN Calibration System  
310-10-61 W93-70530  
Networks Communication Technology  
310-20-38 W93-70536  
Mission Operations Technology  
310-40-45 W93-70546  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549  
Advanced Telemetry Processing Technology  
310-40-51 W93-70550  
DSN Data Processing and Productivity  
310-40-73 W93-70551

**COMPUTER PROGRAMS**

Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Computational Aerosciences  
509-10-00 W93-70028  
Computational Aerosciences  
509-10-00 W93-70030  
Computational/Aeroscience  
509-10-00 W93-70031  
Earth and Space Sciences  
509-20-00 W93-70033  
Earth and Space Sciences  
509-20-00 W93-70034  
Advanced Composite Materials Technology  
510-02-00 W93-70037  
Emissions and Source Noise  
537-02-00 W93-70054  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Hypersonics Research and Technology  
506-73-00 W93-70100

Automation and Robotics  
586-02-00 W93-70131  
Automation and Robotics  
586-02-00 W93-70132  
Automation and Robotics  
586-02-00 W93-70133  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
Mars Surface and Atmosphere Studies  
155-04-00 W93-70162  
UV Astronomy and Data Systems  
188-41-51 W93-70189  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Theory and Modeling: Infrared, Submillimeter, and  
Radio  
188-44-53 W93-70200  
Musculoskeletal  
199-26-14 W93-70238  
Forest/Climate Interactions  
462-21-00 W93-70337  
Geopotential Temporal Variations  
465-17-02 W93-70400  
JPL Oceanography Group Common Computer System  
578-22-27 W93-70434  
LTP Computer Support  
579-41-04 W93-70465  
Data System Integration (Commonality and  
Interoperability)  
656-61-02 W93-70478  
Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480  
Science Digital Data Preservation  
656-61-07 W93-70482  
Graphical Methods for Science Visualization and Data  
Analysis  
656-65-05 W93-70489  
Construction of an Advanced Software Tool for Planetary  
Atmospheric Modeling  
656-65-24 W93-70494  
A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496  
A Distributed Analysis and Visualization System for  
Model and Observational Data  
656-65-27 W93-70497  
Software Engineering Technology  
310-10-23 W93-70527  
Flight Dynamics Technology  
310-10-26 W93-70528

**COMPUTER STORAGE DEVICES**  
Information and Communications  
586-03-00 W93-70137

**COMPUTER SYSTEMS DESIGN**  
Computational Aerosciences  
509-10-00 W93-70029  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063  
Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464  
Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480  
Software Engineering Technology  
310-10-23 W93-70527  
DSN Data Processing and Productivity  
310-40-73 W93-70551

**COMPUTER SYSTEMS PERFORMANCE**  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464

**COMPUTER SYSTEMS PROGRAMS**  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Computational Aerosciences  
509-10-00 W93-70029  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70131  
Space Systems and Navigation Technology  
310-10-63 W93-70532

**COMPUTER TECHNIQUES**  
Interdisciplinary Technology  
505-90-00 W93-70024  
Interdisciplinary Technology  
505-90-00 W93-70027  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Automation and Robotics  
586-02-00 W93-70130

Information and Communications  
586-02-00 W93-70134  
Planetary Materials: General Operations and Laboratory  
Facilities  
152-30-40 W93-70150  
UV Astronomy and Data Systems  
188-41-51 W93-70189  
Research Computing Facility and Cataloging for  
Infrared  
188-44-01 W93-70192  
Theory and Modeling: Infrared, Submillimeter, and  
Radio  
188-44-53 W93-70200  
Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464  
Science Digital Data Preservation  
656-61-07 W93-70482  
Center of Excellence for Space Data Information  
Sciences (CESDIS)  
656-65-07 W93-70491  
Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495  
Software Engineering Technology  
310-10-23 W93-70527  
Networks Communication Technology  
310-20-38 W93-70536  
**COMPUTER VISION**  
Controls, Guidance, and Human Factors Research and  
Technology  
505-64-00 W93-70010  
**COMPUTERIZED SIMULATION**  
Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Systems Analysis  
505-69-00 W93-70016  
Systems Analysis  
505-69-00 W93-70018  
Interdisciplinary Technology  
505-90-00 W93-70026  
Computational Aerosciences  
509-10-00 W93-70028  
Computational Aerosciences  
509-10-00 W93-70030  
Computational/Aeroscience  
509-10-00 W93-70031  
Earth and Space Sciences  
509-20-00 W93-70033  
Earth and Space Sciences  
509-20-00 W93-70034  
Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047  
NAS Operations  
536-02-00 W93-70048  
Emissions and Source Noise  
537-02-00 W93-70054  
Propulsion Research and Technology  
506-42-00 W93-70069  
Systems Analysis  
506-49-00 W93-70084  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Prebiotic Evolution  
199-52-22 W93-70247  
Space Physics Theory Program  
431-06-00 W93-70291  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303  
Origins of Solar Systems  
452-23-94 W93-70305  
Forest/Climate Interactions  
462-21-00 W93-70337  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430  
Simulation of Tropospheric Ozone  
579-24-00 W93-70453  
Biogeochemistry and Geophysics Modeling and Data  
Analysis  
579-42-01 W93-70467  
A Distributed Analysis and Visualization System for  
Model and Observational Data  
656-65-27 W93-70497

Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517  
Communication Systems Research  
310-30-71 W93-70544  
DSN Data Processing and Productivity  
310-40-73 W93-70551  
**COMPUTERS**  
Aerodynamics Research and Technology  
505-59-00 W93-70002  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063  
Systems Analysis  
506-49-00 W93-70084  
Automation and Robotics  
586-02-00 W93-70133  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
NASA/IPAC Extragalactic Database  
399-20-00 W93-70259  
A 4D Data Assimilation for EOS Computer Support  
428-81-04 W93-70262  
JPL Oceanography Group Common Computer System  
578-22-27 W93-70434  
LTP Computer Support  
579-41-04 W93-70465  
**CONCENTRATION (COMPOSITION)**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
Global Assessment of Active Volcanism  
429-81-97 W93-70288  
**CONCURRENT PROCESSING**  
Computational Aerosciences  
509-10-00 W93-70029  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498  
**CONDUCTIVITY**  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458  
Fluid Physics  
674-24-08 W93-70512  
**CONES (VOLCANOES)**  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
**CONFERENCES**  
Hypersonic Training and Research  
505-70-00 W93-70021  
Propulsion Research and Technology  
506-42-00 W93-70069  
Study of Potential Mars Observer - Mars 94, 96 Flight  
Path Cooperatives  
152-88-10 W93-70151  
Oceanic Remote Sensing Library  
461-66-16 W93-70335  
Information Systems Newsletter  
656-50-65 W93-70477  
**CONFIDENCE LIMITS**  
Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537  
**CONFERS**  
Satellite Radar for Forest Structure  
462-41-61 W93-70343  
Biogeochemical Cycling Research on the Oregon  
Transect  
462-43-00 W93-70344  
Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345  
Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363  
**CONNECTIVE TISSUE**  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237  
**CONSERVATION LAWS**  
Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416  
**CONSOLIDATION**  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180  
**CONSTANTS**  
Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376  
**CONTAINERS**  
Glasses and Ceramics  
674-26-08 W93-70516  
**CONTAMINATION**  
Space Flight Research and Technology  
506-48-00 W93-70080  
Optical Technology for Space Astronomy  
188-41-23 W93-70186

**CONTINENTS**  
Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470  
**CONTINUOUS RADIATION**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
**CONTINUOUS SPECTRA**  
Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204  
**CONTRACT MANAGEMENT**  
Propulsion Research and Technology  
506-42-00 W93-70069  
Process Studies: Radiation Dynamics and Hydrology,  
Radiation and Dynamic Processes  
460-20-00 W93-70308  
**CONTRACTORS**  
Stratospheric Observatory for Infrared Astronomy  
(SOFIA)  
188-78-60 W93-70216  
Hydrologic Process Studies  
461-50-00 W93-70330  
**CONTRAROTATING PROPELLERS**  
Advanced Turboprop Systems  
535-03-00 W93-70045  
**CONTROL EQUIPMENT**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
**CONTROL STABILITY**  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
**CONTROL SURFACES**  
Aerodynamics Research and Technology  
505-59-00 W93-70003  
**CONTROL SYSTEMS DESIGN**  
High-Performance Flight Research  
533-02-00 W93-70041  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Surface Systems  
583-02-00 W93-70116  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
Automation and Robotics  
586-02-00 W93-70130  
Information and Communications  
586-02-00 W93-70134  
**CONTROL THEORY**  
Flight Systems Research and Technology  
505-68-00 W93-70015  
Information and Controls Research and Technology  
506-59-00 W93-70087  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70089  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Information and Controls Research and Technology  
506-59-00 W93-70092  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
**CONTROLLABILITY**  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
**CONTROLLED ATMOSPHERES**  
Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254  
**CONTROLLERS**  
Information and Communications  
586-03-00 W93-70135  
Data Storage Technology  
310-40-48 W93-70548  
**CONVECTION**  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
Measurement of Volcanic Gases  
465-44-05 W93-70414  
Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423  
Global Climate Modeling  
578-41-01 W93-70442  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-03 W93-70501  
Electronic Materials  
674-21-08 W93-70506



## CONVECTION CLOUDS

Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158

## CONVECTIVE FLOW

Convective Transport in the Solar Nebula  
452-22-91 W93-70303  
Glasses and Ceramics  
674-26-08 W93-70516

## CONVECTIVE HEAT TRANSFER

Aerothermodynamics Research and Technology  
506-40-00 W93-70063

## CONVERGENCE

Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389

## COOLING

Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451

## COOLING SYSTEMS

Observatory Systems  
582-04-00 W93-70114  
Observatory Systems  
582-04-00 W93-70115  
Planetary Instrument Development Program/Planetary  
Astronomy High Temperature Superconductor  
Bolometers  
157-05-50 W93-70175  
Radio Systems Development  
310-20-66 W93-70540

## COORDINATE TRANSFORMATIONS

Theory of Geodetic Transformations  
465-15-06 W93-70398

## COORDINATES

HIPPARCOS VLBI  
399-18-00 W93-70256  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
North American Fiducial Network  
465-14-11 W93-70397

## COORDINATION

Study of Potential Mars Observer - Mars 94, 96 Flight  
Path Cooperatives  
152-88-10 W93-70151  
Information Systems Newsletter  
656-50-65 W93-70477  
Planetary Hardcopy Preservation Task  
656-61-20 W93-70486  
Center of Excellence for Space Data Information  
Sciences (CESDIS)  
656-65-07 W93-70491

## CORE FLOW

Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

## CORONAGRAPHS

SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521

## CORONAL HOLES

Ground-Based Support of Solar Physics  
170-38-52 W93-70179

## CORONAS

Solar Physics Studies  
170-38-53 W93-70181

## CORRECTION

Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Problems in Interpreting Satellite Crustal Anomaly Field  
Data  
579-31-01 W93-70456

## CORRELATION

Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145  
High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205  
GPS/VLBI Vertical Measurement  
465-14-09 W93-70396  
Geopotential Temporal Variations  
465-17-02 W93-70400  
Graphical Methods for Science Visualization and Data  
Analysis  
656-65-05 W93-70489

## CORROSION

Aging Aircraft  
538-02-00 W93-70061  
Materials and Structures Research and Technology  
506-43-00 W93-70071

## COSMIC BACKGROUND EXPLORER SATELLITE

Energetics of Interstellar Clouds  
399-20-00 W93-70257

## COSMIC DUST

Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials: Collection, Preservation and  
Distribution  
152-20-40 W93-70149  
Properties of Interstellar PAH's  
188-44-57 W93-70202  
Laboratory Astrophysics  
188-44-57 W93-70203  
Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245  
Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246  
Exobiology Intact Capture Technology Development  
199-52-54 W93-70250  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
Center for Star Formation Studies  
399-20-01 W93-70260  
The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons  
399-50-00 W93-70261

## COSMIC RAYS

Information and Controls Research and Technology  
506-59-00 W93-70090  
Observatory Systems  
582-04-00 W93-70115  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Gamma Ray Astronomy  
188-46-57 W93-70207  
Radiation Health  
199-04-11 W93-70226  
Space Radiation  
199-04-14 W93-70228

## COSMIC X RAYS

High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205

## COSMOLOGY

Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205

## COST ANALYSIS

Atmospheric Effects  
537-01-00 W93-70049  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Integral Mission Definition Study  
188-78-01 W93-70211  
Optical Interferometry in Space  
188-78-41 W93-70213  
Flight Research  
199-40-72 W93-70244  
Oceanic Remote Sensing Library  
461-66-16 W93-70335

## COST EFFECTIVENESS

Advanced Composite Materials Technology  
510-02-00 W93-70038  
Information and Controls Research and Technology  
506-59-00 W93-70092  
In-Space Technology Experiments  
506-74-00 W93-70103  
Space Transportation  
584-04-00 W93-70122  
Automation and Robotics  
586-02-00 W93-70127  
Information and Communications  
586-02-00 W93-70134  
Flight Research  
199-40-72 W93-70244  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Data System Integration (Commonality and  
Interoperability)  
656-61-02 W93-70478

Antenna Systems Development  
310-20-65 W93-70539  
Data Storage Technology  
310-40-48 W93-70548

## COST ESTIMATES

Optical Interferometry in Space  
188-78-41 W93-70213  
Solar Probe ATD  
433-06-00 W93-70296  
AVIRIS Operations  
463-75-63 W93-70364  
AVIRIS Operations  
465-65-01 W93-70417

## COST REDUCTION

Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Earth-to-Orbit Transportation  
584-03-00 W93-70120  
Space Transportation  
584-04-00 W93-70123  
Optical Interferometry in Space  
188-78-41 W93-70213  
Data System Integration (Commonality and  
Interoperability)  
656-61-02 W93-70478  
Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480  
Advanced Transmitter Systems Development  
310-20-64 W93-70538  
DSN Data Processing and Productivity  
310-40-73 W93-70551

## COSTS

Ocean Color Data System  
428-82-06 W93-70272  
Mission Operations Technology  
310-40-45 W93-70546  
Data Storage Technology  
310-40-48 W93-70548

## COVARIANCE

Study of Potential Mars Observer - Mars 94, 96 Flight  
Path Cooperatives  
152-88-10 W93-70151

## CRACKS

Aging Aircraft  
538-02-00 W93-70061  
Automation and Robotics  
586-02-00 W93-70133

## CRATERS

Early Mars: Impact Basins, Crustal Dichotomy, Volcanic  
Resurfacing  
151-02-00 W93-70140  
Evolution of Volcanic Terrains  
465-44-02 W93-70412

## CREEP PROPERTIES

Materials and Structures Research and Technology  
505-63-00 W93-70007  
Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402

## CREW WORKSTATIONS

Space Human Factors Behavior and Performance  
199-06-11 W93-70229

## CRITICAL EXPERIMENTS

Metals and Alloys  
674-25-08 W93-70514

## CROSS CORRELATION

Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495

## CROSS POLARIZATION

Scatterometer Research  
461-31-09 W93-70323

## CROSSLINKING

Space Communications Research and Technology  
506-72-00 W93-70098  
Optical Communications  
310-20-35 W93-70533

## CRUISE MISSILES

GA/Commuter Engine Technology  
535-05-00 W93-70046

## CRUSTAL FRACTURES

Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
Parkfield GPS Experiment  
465-13-08 W93-70393  
Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395

Short-Period Tropospheric Noise in Continuous GPS Measurements 465-27-02	W93-70402		
<b>CRUSTS</b>			
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing 151-02-00	W93-70140		
<b>CRYOGENIC COOLING</b>			
Observatory Systems 582-04-00	W93-70114		
<b>CRYOGENIC EQUIPMENT</b>			
System Analysis 506-49-00	W93-70083		
Earth-to-Orbit Transportation 584-03-00	W93-70120		
Space Transportation 584-04-00	W93-70122		
Space Transportation 584-04-00	W93-70123		
Frequency and Timing Research 310-10-62	W93-70531		
<b>CRYOGENIC FLUID STORAGE</b>			
Materials and Structures Research and Technology 506-43-00	W93-70071		
System Analysis 506-49-00	W93-70083		
Earth-to-Orbit Transportation 584-03-00	W93-70120		
<b>CRYOGENIC FLUIDS</b>			
Propulsion Research and Technology 506-42-00	W93-70068		
In-Space Technology Experiments 506-74-00	W93-70103		
Observatory Systems 582-04-00	W93-70114		
<b>CRYOGENIC TEMPERATURE</b>			
Materials and Structures Research and Technology 506-43-00	W93-70074		
IR Astronomy ATD/Cryo Optical Testing and Science Support Activities 188-78-44	W93-70214		
<b>CRYOGENICS</b>			
Space Energy Conversion Research and Technology 506-41-00	W93-70066		
Propulsion Research and Technology 506-42-00	W93-70068		
Science Sensing (Remote) 582-03-00	W93-70111		
Ground-Based Infrared Astronomy 196-41-50	W93-70218		
<b>CRYOSTATS</b>			
Laboratory Astrophysics 188-44-57	W93-70203		
<b>CRYSTAL DEFECTS</b>			
Electronic Materials 674-21-08	W93-70506		
<b>CRYSTAL GROWTH</b>			
A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains 152-12-40	W93-70143		
Electronic Materials 674-21-05	W93-70505		
Electronic Materials 674-21-08	W93-70506		
Metals and Alloys 674-25-05	W93-70513		
Metals and Alloys 674-25-08	W93-70514		
<b>CRYSTAL OPTICS</b>			
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis 656-65-25	W93-70495		
<b>CRYSTAL STRUCTURE</b>			
A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains 152-12-40	W93-70143		
Microgravity Nucleation and Particle Coagulation Experiments 152-20-01	W93-70148		
Band Structure Engineering on Silicon CCDs for Enhanced UV Response 188-41-24	W93-70188		
Electronic Materials 674-21-05	W93-70505		
Metals and Alloys 674-25-05	W93-70513		
<b>CRYSTALLINITY</b>			
Electronic Materials 674-21-08	W93-70506		
<b>CRYSTALLIZATION</b>			
Planetary Materials: Experimental Petrology 152-12-40	W93-70142		
Biotechnology 674-23-08	W93-70509		
<b>CURRENT DENSITY</b>			
In-Space Technology Experiments 506-74-00	W93-70107		
<b>CYCLES</b>			
Biogeochemical Cycling Research on the Oregon Transect 462-43-00	W93-70344		
Biogeochemical Research in Temperate Ecosystems 462-43-00	W93-70345		
<b>CYCLIC HYDROCARBONS</b>			
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals 188-41-57	W93-70190		
Properties of Interstellar PAH's 188-44-57	W93-70202		
Center for Star Formation Studies 399-20-01	W93-70260		
The Nature of Interstellar Dust, Ices and Polycyclic Aromatic Hydrocarbons 399-50-00	W93-70261		
<b>CYCLOONES</b>			
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis 578-10-00	W93-70421		
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling 578-40-00	W93-70441		
<b>CYTOLOGY</b>			
Cell and Development Biology 199-40-21	W93-70239		
Cell and Developmental Biology 199-40-22	W93-70240		
Integrative Biology 199-40-32	W93-70241		
Structural Biosystems 199-40-42	W93-70242		
Biotechnology Research 674-23-01	W93-70508		
<b>D</b>			
<b>DAMAGE</b>			
Advanced Composite Materials Technology 510-02-00	W93-70037		
Advanced Rotorcraft Technology 532-06-00	W93-70040		
Automation and Robotics 586-02-00	W93-70133		
<b>DATA ACQUISITION</b>			
Space Flight Research and Technology 506-48-00	W93-70079		
Space Flight Research and Technology 506-48-00	W93-70081		
Space Data Systems 586-03-00	W93-70136		
U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy 155-20-02	W93-70166		
Imaging Studies of Comets 196-41-52	W93-70219		
Volatiles in the Solar System 196-41-67	W93-70221		
Hydrologic Processes, Field Study 461-10-00	W93-70318		
Airborne Precipitation Radar 461-51-16	W93-70332		
Ice Sheet Geophysical Investigations Using Imaging Radar 461-66-18	W93-70336		
Airborne Synthetic Aperture Radar (AIRSAR) Operations 462-75-62	W93-70351		
Airborne Science Management Operating Working Group Support 462-79-00	W93-70354		
AVIRIS Operations 463-75-63	W93-70364		
Laser Diode Sensor 464-11-07	W93-70366		
Remote Sensing of Active and Recently Active Volcanic Features 465-44-01	W93-70411		
AVIRIS Operations 465-65-01	W93-70417		
Airborne Synthetic Aperture Radar (AIRSAR) Operations 465-68-01	W93-70420		
Problems in Interpreting Satellite Crustal Anomaly Field Data 579-31-01	W93-70456		
Satellite Data Sets and Algorithm Testing 579-42-11	W93-70470		
Space Physics Data System 656-61-18	W93-70485		
Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data 656-65-22	W93-70493		
Astrometric Development Technology 310-10-60	W93-70529		
Advanced Environments for Software and System Development 310-40-49	W93-70549		
<b>DATA BASE MANAGEMENT SYSTEMS</b>			
Information and Controls Research and Technology 506-59-00	W93-70091		
Planetary Data System 155-20-00	W93-70165		
Human-to-Machine Interface Technology 310-40-37	W93-70545		
<b>DATA BASES</b>			
Applied Aerodynamics Research and Technology 505-59-00	W93-70001		
Advanced Rotorcraft Technology 532-06-00	W93-70039		
Emissions and Source Noise 537-02-00	W93-70055		
Aerothermodynamics Research and Technology 506-40-00	W93-70063		
Information and Controls Research and Technology 506-59-00	W93-70088		
Information and Controls Research and Technology 506-59-00	W93-70090		
Hypersonics Research and Technology 506-73-00	W93-70100		
UV Astronomy and Data Systems 188-41-51	W93-70189		
High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies 188-46-01	W93-70205		
Longitudinal Studies (Medical Operations Longitudinal Studies) 199-02-31	W93-70224		
Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions 370-03-00	W93-70255		
IPAC Astrophysics Data System (ADS) Support 399-20-00	W93-70258		
NASA/IPAC Extragalactic Database 399-20-00	W93-70259		
Studies of Volcanic SO2 428-81-99	W93-70271		
Interannual Variability of Global Cycles 429-81-06	W93-70276		
Biosphere Atmospheric Interactions 429-81-26	W93-70279		
Global Assessment of Active Volcanism 429-81-94	W93-70285		
Desert Mesoscale/PBL 461-13-02	W93-70322		
Scatterometer Studies 461-31-13	W93-70324		
Oceanic Remote Sensing Library 461-66-16	W93-70335		
Phytoplankton Dynamics of North Pacific Ocean 463-11-09	W93-70356		
Bio-Optical Interpretation of Ocean Color Imagery 463-11-62	W93-70357		
Biogeochemical Research in Temperate Ecosystems 463-67-00	W93-70363		
NDSC Differential Absorption Lidar 464-13-15	W93-70371		
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research 464-23-10	W93-70383		
Geological Interpretation of Magsat Anomaly Data 465-32-06	W93-70405		
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula 465-42-06	W93-70408		
Satellite Observations of Volcanic Aerosols 465-44-00	W93-70410		
Measurement of Volcanic Gases 465-44-05	W93-70414		
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis 578-10-00	W93-70421		
Studies of Sea Surface Temperature and Topography 578-22-25	W93-70432		
LTP Computer Support 579-41-04	W93-70465		
ERS-1 Studies of Forest Ecosystems 579-41-08	W93-70466		
Landsat Land Cover Pathfinder 579-98-00	W93-70476		
Planetary Hardcopy Preservation Task 656-61-20	W93-70486		
Data Management Initiative - National Space Science Data Center 656-61-21	W93-70487		

DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases  
 656-65-21 W93-70492  
 Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
 656-65-22 W93-70493  
 Construction of an Advanced Software Tool for Planetary Atmospheric Modeling  
 656-65-24 W93-70494  
 Windows on Global Change  
 665-82-03 W93-70503  
 Consulting and Program Support  
 674-29-08 W93-70520

**DATA COMPRESSION**

Space Data Systems  
 586-03-00 W93-70136  
 Information and Communications  
 586-03-00 W93-70137

**DATA CONVERSION ROUTINES**

Science Digital Data Preservation  
 656-61-07 W93-70482

**DATA CORRELATION**

Space Energy Conversion Research and Technology  
 506-41-00 W93-70066  
 Sounding Rocket Experiments  
 879-11-38 W93-70522

**DATA LINKS**

Space Communications Research and Technology  
 506-72-00 W93-70096  
 Space Communications Research and Technology  
 506-72-00 W93-70098  
 Telepresence for Planetary Exploration  
 186-06-01 W93-70182  
 Optical Communications  
 310-20-35 W93-70533  
 Advanced Space Systems for Users of NASA Networks  
 310-20-46 W93-70537  
 Advanced Environments for Software and System Development  
 310-40-49 W93-70549

**DATA MANAGEMENT**

Earth and Space Sciences  
 509-20-00 W93-70034  
 U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
 155-20-02 W93-70166  
 Stratospheric Processes and Atmospheric Chemistry Studies  
 464-14-00 W93-70373  
 JPL Oceanography Group Common Computer System  
 578-22-27 W93-70434  
 Crustal Dynamics Data Information System (CDDIS)  
 579-32-06 W93-70459  
 Navigation Ancillary Information Facility (NAIF)  
 656-61-05 W93-70480  
 PDS: Data Distribution and Archive Technology  
 656-61-06 W93-70481  
 Science Digital Data Preservation  
 656-61-07 W93-70482  
 NSSDC Astrophysics Data Systems Support  
 656-61-17 W93-70484  
 Data Management Initiative - National Space Science Data Center  
 656-61-21 W93-70487  
 Image Animation Laboratory for Science Visualization  
 656-65-04 W93-70488  
 Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
 656-65-06 W93-70490  
 Center of Excellence for Space Data Information Sciences (CESDIS)  
 656-65-07 W93-70491  
 DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases  
 656-65-21 W93-70492  
 Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
 656-65-22 W93-70493  
 Construction of an Advanced Software Tool for Planetary Atmospheric Modeling  
 656-65-24 W93-70494  
 A Spatial Analysis and Modeling System for Environmental Management  
 656-65-26 W93-70496  
 Concurrent Processing Testbed - Science Analysis  
 656-74-03 W93-70498

**DATA PROCESSING**

Aerothermodynamics Research and Technology  
 506-40-00 W93-70063  
 Information and Controls Research and Technology  
 506-59-00 W93-70089

Automation and Robotics  
 586-02-00 W93-70130  
 Information and Communications  
 586-03-00 W93-70135  
 Mars Data Analysis  
 155-20-00 W93-70164  
 Research Computing Facility and Cataloging for Infrared  
 188-44-01 W93-70192  
 High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies  
 188-46-01 W93-70205  
 Bioregenerative Life Support Research (CELSS)  
 199-61-12 W93-70254  
 Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions  
 370-03-00 W93-70255  
 A 4D Data Assimilation for EOS Computer Support  
 428-81-04 W93-70262  
 Automated Geophysical Processor Development for the Alaska SAR Facility  
 428-82-11 W93-70273  
 Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
 432-20-00 W93-70292  
 CO2 Lidar Backscatter Experiment  
 460-21-00 W93-70309  
 Airborne Precipitation Radar  
 461-51-16 W93-70332  
 Polarimetric Data Analysis  
 461-64-11 W93-70334  
 Ice Sheet Geophysical Investigations Using Imaging Radar  
 461-66-18 W93-70336  
 Airborne Synthetic Aperture Radar (AIRSAR) Operations  
 462-75-62 W93-70351  
 SeaWiFS Calibration/Validation  
 463-11-01 W93-70355  
 Airborne Oceanographic Lidar (AOL)  
 463-11-79 W93-70358  
 North American Fiducial Network  
 465-14-11 W93-70397  
 Theory of Geodetic Transformations  
 465-15-06 W93-70398  
 Airborne Synthetic Aperture Radar (AIRSAR) Operations  
 465-68-01 W93-70420  
 Tropical Ocean Circulation from Altimetry and Numerical Modeling  
 578-21-12 W93-70430  
 Ocean Circulation from Satellite Altimetry  
 578-22-24 W93-70431  
 Active/Passive Sea Ice Analysis  
 578-32-24 W93-70437  
 Modeling and Data Analysis, Climate and Hydrology Cryosphere Studies  
 578-90-00 W93-70445  
 Hydrospheric Processes Program Support for Modeling and Data Analysis  
 578-97-12 W93-70446  
 Satellite Data Sets and Algorithm Testing  
 579-42-11 W93-70470  
 Graphical Methods for Science Visualization and Data Analysis  
 656-65-05 W93-70489  
 Flight Dynamics Technology  
 310-10-26 W93-70528  
 Space Systems and Navigation Technology  
 310-10-63 W93-70532  
 Mission Operations Technology  
 310-40-45 W93-70546  
 Advanced Environments for Software and System Development  
 310-40-49 W93-70549  
 DSN Data Processing and Productivity  
 310-40-73 W93-70551

**DATA PROCESSING EQUIPMENT**

Space Systems and Navigation Technology  
 310-10-63 W93-70532  
 Human-to-Machine Interface Technology  
 310-40-37 W93-70545

**DATA REDUCTION**

Automation and Robotics  
 586-02-00 W93-70131  
 Planetary Atmospheric Composition, Structure, and History  
 154-10-80 W93-70152  
 Mars Surface and Atmosphere Studies  
 155-04-00 W93-70162  
 Planetary Data System  
 155-20-00 W93-70165  
 Optical Stellar Interferometry  
 188-41-21 W93-70184  
 UV Astronomy and Data Systems  
 188-41-51 W93-70189

Research Computing Facility and Cataloging for Infrared  
 188-44-01 W93-70192  
 Theory and Modeling: Infrared, Submillimeter, and Radio  
 188-44-53 W93-70200  
 High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies  
 188-46-01 W93-70205  
 Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions  
 370-03-00 W93-70255  
 A 4D Data Assimilation for EOS Computer Support  
 428-81-04 W93-70262  
 Global Hydrologic Cycle  
 429-81-16 W93-70278  
 Polar Exchange at the Sea Surface: JPL Component  
 429-81-64 W93-70282  
 Polarimetric Data Analysis  
 461-64-11 W93-70334  
 Airborne Oceanographic Lidar (AOL)  
 463-11-79 W93-70358  
 Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements  
 464-23-08 W93-70381  
 Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
 465-13-06 W93-70392  
 LTP Visualization  
 578-97-53 W93-70449  
 Satellite Data Sets and Algorithm Testing  
 579-42-11 W93-70470  
 Neptune Data Analysis  
 889-59-00 W93-70524  
 Neptune Data Analysis  
 889-59-00 W93-70525

**DATA RETRIEVAL**

Meteorological Parameters Extraction  
 578-12-20 W93-70427

**DATA SIMULATION**

Project to Interface Modeling: EOSDIS Activities  
 428-81-72 W93-70267

**DATA STORAGE**

LTP Visualization  
 578-97-53 W93-70449  
 Crustal Dynamics Data Information System (CDDIS)  
 579-32-06 W93-70459  
 Computer and Information Systems Support  
 579-82-90 W93-70474  
 PDS: Data Distribution and Archive Technology  
 656-61-06 W93-70481  
 Science Digital Data Preservation  
 656-61-07 W93-70482  
 Planetary Hardcopy Preservation Task  
 656-61-20 W93-70486  
 Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
 656-65-06 W93-70490  
 Advanced Space Systems for Users of NASA Networks  
 310-20-46 W93-70537  
 Data Storage Technology  
 310-40-48 W93-70548

**DATA STRUCTURES**

Data Interchange Standards  
 656-61-03 W93-70479  
 Image Animation Laboratory for Science Visualization  
 656-65-04 W93-70488

**DATA SYSTEMS**

Space Flight Research and Technology  
 506-48-00 W93-70079  
 Information and Controls Research and Technology  
 506-59-00 W93-70088  
 Information and Controls Research and Technology  
 506-59-00 W93-70091  
 Automation and Robotics  
 586-02-00 W93-70131  
 Information and Communications  
 586-03-00 W93-70135  
 Space Data Systems  
 586-03-00 W93-70136  
 Information and Communications  
 586-03-00 W93-70137  
 Planetary Data System  
 155-20-00 W93-70165  
 U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
 155-20-02 W93-70166  
 UV Astronomy and Data Systems  
 188-41-51 W93-70189  
 IPAC Astrophysics Data System (ADS) Support  
 399-20-00 W93-70258  
 Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
 428-81-10 W93-70263

- Ocean Color Data System  
428-82-06 W93-70272  
Automated Geophysical Processor Development for the  
Alaska SAR Facility W93-70273  
428-82-11  
4D Data Assimilation for EOS W93-70275  
429-81-04  
Interannual Variability of Global Cycles W93-70276  
429-81-06  
Radar-Allimeter Ice Data System W93-70448  
578-97-20  
Crustal Dynamics Data Information System (CDDIS) W93-70459  
579-32-06  
Data System Integration (Commonality and  
Interoperability) W93-70478  
656-61-02  
Data Interchange Standards W93-70479  
656-61-03  
PDS: Data Distribution and Archive Technology W93-70481  
656-61-06  
Science Digital Data Preservation W93-70482  
656-61-07  
SS Freedom Archive Planning Study W93-70483  
656-61-13  
NSSDC Astrophysics Data Systems Support W93-70484  
656-61-17  
Space Physics Data System W93-70485  
656-61-18  
Graphical Methods for Science Visualization and Data  
Analysis W93-70489  
656-65-05  
A Spatial Analysis and Modeling System for  
Environmental Management W93-70496  
656-65-26  
Planning and Scheduling Systems Technology W93-70534  
310-20-36  
Expert Systems for Automation of Operations W93-70547  
310-40-47  
Advanced Environments for Software and System  
Development W93-70549  
310-40-49  
Advanced Telemetry Processing Technology W93-70550  
310-40-51
- DATA TRANSMISSION**  
Communication Systems Research W93-70544  
310-30-71
- DECIDUOUS TREES**  
Satellite Radar for Forest Structure W93-70343  
462-41-61
- DECISION MAKING**  
Controls, Guidance and Human Factors Research and  
Technology W93-70011  
505-64-00  
Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis W93-70495  
656-65-25  
Expert Systems for Automation of Operations W93-70547  
310-40-47
- DECODERS**  
Communication Systems Research W93-70544  
310-30-71
- DECODING**  
Development of UV Photon Counting Geometrically  
Stable Array Detector - Multi-Anode Microchannel Array  
(MAMA) W93-70187  
188-41-24
- DECONDITIONING**  
Clinical Medicine Technology Watch W93-70223  
199-02-31  
Cardiopulmonary Physiology W93-70233  
199-14-12
- DEEP SPACE**  
Space Energy Conversion Research and Technology W93-70064  
506-41-00  
Infrared/Radio Research W93-70193  
188-44-21  
Goldstone DOSE Support W93-70403  
465-28-02
- DEEP SPACE NETWORK**  
Study of Potential Mars Observer - Mars 94, 96 Flight  
Path Cooperatives W93-70151  
152-88-10  
Infrared/Radio Research W93-70193  
188-44-21  
Global Tectonic Motions W93-70394  
465-14-01  
Astrometric Development Technology W93-70529  
310-10-60  
GPS-Based DSN Calibration System W93-70530  
310-10-61  
Frequency and Timing Research W93-70531  
310-10-62  
Space Systems and Navigation Technology W93-70532  
310-10-63  
Planning and Scheduling Systems Technology W93-70534  
310-20-36
- Advanced Transmitter Systems Development W93-70538  
310-20-64  
Antenna Systems Development W93-70539  
310-20-65  
Radio Systems Development W93-70540  
310-20-66  
Optical Communications Technology Development W93-70541  
310-20-67  
DSS 13 Instrumentation and Capabilities W93-70542  
310-30-69  
Network Signal Processing W93-70543  
310-30-70  
Communication Systems Research W93-70544  
310-30-71  
DSN Data Processing and Productivity W93-70551  
310-40-73
- DEEP WATER**  
Climate Stability: The Role of the Hydrological Cycle  
and the Thermohaline Circulation W93-70436  
578-31-14
- DEFORESTATION**  
Foreign Visitor Support W93-70290  
429-97-04
- DEFORMATION**  
Crustal Strain Modeling Using Finite Element Methods W93-70388  
465-12-03  
Modeling of Convergent Plate Margin Deformation W93-70389  
465-12-06  
Dynamics of North American-Pacific Shear W93-70390  
465-13-02  
Active Deformation in the Mojave Desert and Walker  
Lane: A Global Positioning System Experiment W93-70392  
465-13-06  
Global Tectonic Motions W93-70394  
465-14-01  
Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints W93-70395  
465-14-07  
Lateral Variations in Solid Tides W93-70401  
465-17-04  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula W93-70408  
465-42-06  
Carbon Mass Balance During Soil Evolution Along  
Climate Gradients W93-70416  
465-45-01  
Active/Passive Sea Ice Analysis W93-70437  
578-32-24
- DEGRADATION**  
Space Energy Conversion Research and Technology W93-70067  
506-41-00
- DEICERS**  
Flight Systems Research and Technology W93-70014  
505-68-00
- DEICING**  
Flight Systems Research and Technology W93-70014  
505-68-00
- DEIMOS**  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy W93-70166  
155-20-02
- DELAMINATING**  
Advanced Composite Materials Technology W93-70037  
510-02-00
- DELIVERY**  
DSN Data Processing and Productivity W93-70551  
310-40-73
- DEMODULATION**  
Communication Systems Research W93-70544  
310-30-71
- DENDRITIC CRYSTALS**  
Metals and Alloys W93-70514  
674-25-08
- DENSITY DISTRIBUTION**  
SPARTAN 201 White Light Coronagraph W93-70521  
879-10-00
- DEOXYRIBONUCLEIC ACID**  
Space Radiation W93-70228  
199-04-14
- DEPLOYMENT**  
Micro Weather Stations for Mars W93-70174  
157-04-80
- DEPOLARIZATION**  
Scatterometer Research W93-70323  
461-31-09
- DEPOSITION**  
Global Assessment of Active Volcanism W93-70270  
428-81-96  
Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico W93-70409  
465-43-03
- DEPOSITS**  
Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response W93-70188  
188-41-24
- DESERTIFICATION**  
Field Experiment in  
Desertification-Threatened Area (EFEDA) W93-70342  
462-32-61  
Soil Moisture from SAR W93-70349  
462-62-05
- DESERTS**  
Desert Mesoscale/PBL W93-70322  
461-13-02
- DESIGN ANALYSIS**  
Systems Analysis W93-70016  
505-69-00  
Hypersonic Research and Technology W93-70020  
505-70-00  
Computational/Aeroscience W93-70031  
509-10-00  
Advanced Rotorcraft Technology W93-70040  
532-06-00  
High-Performance Flight Research W93-70041  
533-02-00  
Community Noise and Sonic Boom W93-70056  
537-03-00  
Aerothermodynamics Research and Technology W93-70063  
506-40-00  
Space Energy Conversion Research and Technology W93-70067  
506-41-00  
Hypersonics Research and Technology W93-70100  
506-73-00  
Earth-to-Orbit Transportation W93-70118  
584-03-00  
Earth-Orbiting Platforms W93-70124  
585-03-00  
Earth-Orbiting Platforms W93-70125  
585-03-00  
Imaging Spectropolarimeter W93-70170  
157-03-70  
Optical Technology for Space Astronomy W93-70186  
188-41-23  
Communications and Telemetry W93-70535  
310-20-37  
Optical Communications Technology Development W93-70541  
310-20-67
- DESORPTION**  
Laboratory Astrophysics W93-70201  
188-44-57
- DESTRUCTION**  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research W93-70383  
464-23-10
- DETECTION**  
Automation and Robotics W93-70133  
586-02-00  
Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals W93-70190  
188-41-57  
Gravity Wave Mission Definition Study W93-70212  
188-78-01  
Global Assessment of Active Volcanism W93-70269  
428-81-94  
Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere W93-70380  
464-23-00  
Measurement of Volcanic Gases W93-70414  
465-44-05  
Advanced Search and Rescue Techniques W93-70504  
669-30-10
- DEUTERIUM**  
The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons W93-70261  
399-50-00  
Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials W93-70306  
452-33-93
- DIAOTOMIC MOLECULES**  
Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals W93-70190  
188-41-57
- DICHOTOMIES**  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic  
Resurfacing W93-70140  
151-02-00
- DICHROISM**  
Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere W93-70380  
464-23-00  
Advanced Transmitter Systems Development W93-70538  
310-20-64
- DIELECTRIC PROPERTIES**  
Measuring Soil Moisture With Imaging Radar W93-70320  
461-13-00  
Fluid Physics W93-70512  
674-24-08
- DIELECTRICS**  
Frequency and Timing Research W93-70531  
310-10-62

**DIFFRACTION**

IR Astronomy ATD/Cryo Optical Testing and Science Support Activities W93-70214

**DIFFUSION**

An Ocean General Circulation Model for Climate Studies W93-70443  
Geomagnetic Modeling of Core Fluid Motions W93-70458

**DIGITAL DATA**

Space Communications Research and Technology W93-70098  
Airborne Interferometric Topography W93-70350  
Airborne Interferometric Topography W93-70419  
Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate W93-70439  
Science Digital Data Preservation W93-70482

**DIGITAL ELECTRONICS**

Space Energy Conversion Research and Technology W93-70067

**DIGITAL SYSTEMS**

Controls, Guidance and Human Factors Research and Technology W93-70011  
Fly-By-Light/Power-By-Wire W93-70060  
Networks Communication Technology W93-70536  
DSS 13 Instrumentation and Capabilities W93-70542  
Network Signal Processing W93-70543

**DIGITAL TECHNIQUES**

NSSDC Astrophysics Data Systems Support W93-70484

**DIMENSIONAL ANALYSIS**

Image Animation Laboratory for Science Visualization W93-70488

**DIODES**

Information and Communications W93-70135  
Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere W93-70380

**DIRECTIONAL SOLIDIFICATION (CRYSTALS)**

Metals and Alloys W93-70514

**DIRECTORIES**

NASA/IPAC Extragalactic Database W93-70259

**DISASTERS**

Advanced Search and Rescue Techniques W93-70504

**DISEASES**

Longitudinal Studies (Medical Operations Longitudinal Studies) W93-70224

**DISPLACEMENT**

ASF SAR Interferometry W93-70500

**DISPLAY DEVICES**

Controls, Guidance, and Human Factors Research and Technology W93-70010  
Flight Systems Research and Technology W93-70015  
Graphical Methods for Science Visualization and Data Analysis W93-70489  
A Distributed Analysis and Visualization System for Model and Observational Data W93-70497

**DISSOCIATION**

Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals W93-70190

**DISSOLVED GASES**

EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface W93-70268

**DISTRIBUTED PROCESSING**

Concurrent Processing Testbed - Science Analysis W93-70498

**DISTRIBUTION FUNCTIONS**

Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs) W93-70204

**DIURNAL VARIATIONS**

Visiting Scientists W93-70353

Laser Diode Sensor W93-70366

**DMSP SATELLITES**

Validations of Passive Microwave Snow Water Equivalent Algorithm W93-70319  
Global Monthly Mean Ocean Variability W93-70435

**DOCUMENTATION**

NSSDC Astrophysics Data Systems Support W93-70484  
Consulting and Program Support W93-70520

**DOCUMENTS**

Earth Science Advanced Aircraft (ESAA) W93-70317  
Data Management Initiative - National Space Science Data Center W93-70487

**DOPED CRYSTALS**

Band Structure Engineering on Silicon CCDs for Enhanced UV Response W93-70188

**DOPPLER EFFECT**

Science Sensing (Remote) W93-70110  
Advanced Infrared Astronomy W93-70220

**DOPPLER RADAR**

Science Sensing (Remote) W93-70113  
Mars 94 Gravity W93-70167  
CO2 Lidar Backscatter Experiment W93-70309  
Airborne Doppler Lidar W93-70311  
Atmospheric Backscatter Experiment W93-70313  
Wind Measurement Assessment W93-70314

**DOSIMETERS**

In-Space Technology Experiments W93-70106

**DOWNLINKING**

Theoretical Investigation of Stratospheric Particulates W93-70450  
Antenna Systems Development W93-70539  
Radio Systems Development W93-70540  
DSS 13 Instrumentation and Capabilities W93-70542

**DRAG**

Community Noise and Sonic Boom W93-70056

**DRAINAGE**

Biogeochemistry and Geophysics Modeling and Data Analysis W93-70467  
Topography from SEASAT and GEOSAT Overland Altimetry W93-70469

**DRAINAGE PATTERNS**

Ice Sheet Geophysical Investigations Using Imaging Radar W93-70336

**DRIFT RATE**

Global Tectonic Motions W93-70394

**DROP TESTS**

Ground Experiment Operations W93-70519

**DROP TOWERS**

Combustion Science W93-70507  
Ground Experiment Operations W93-70518  
Ground Experiment Operations W93-70519

**DROPS (LIQUIDS)**

Combustion Science W93-70507

**DRUGS**

Cardiopulmonary Physiology W93-70233

**DUCTED FANS**

Advanced Turboprop Systems W93-70045

**DURABILITY**

Advanced Composite Materials Technology W93-70037  
GA/Commuter Engine Technology W93-70046  
Enabling Propulsion Materials W93-70058

Materials and Structures Research and Technology W93-70071

**DUST**

Mars 3-D Global Circulation Model W93-70161  
Mars Surface and Atmosphere Studies W93-70162  
Mars Atmosphere Dust Opacity W93-70163  
Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies) W93-70173  
Solar System Exploration W93-70249

**DUST STORMS**

Planetary Clouds Particulates and Ices W93-70155

**DYE LASERS**

Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals W93-70159  
Laboratory Astrophysics W93-70203

**DYNAMIC CHARACTERISTICS**

Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics W93-70292  
Multidimensional Studies of Tropospheric Clouds W93-70316  
Two-Dimensional Stratospheric Chemical Model - Radiation W93-70451

**DYNAMIC MODELS**

Space Transportation W93-70123  
Concurrent Processing Testbed - Science Analysis W93-70498

**DYNAMIC RANGE**

Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project W93-70274

**DYNAMIC RESPONSE**

Materials and Structures Research and Technology W93-70008  
Hypersonic Research and Technology W93-70020  
Materials and Structures Research and Technology W93-70072  
Earth-Orbiting Platforms W93-70125

**DYNAMIC STRUCTURAL ANALYSIS**

Materials and Structures Research and Technology W93-70072

**DYNAMICAL SYSTEMS**

Earth-Orbiting Platforms W93-70124  
Advanced Programs Theoretical Biology W93-70252

**DYNAMICS EXPLORER 1 SATELLITE**

Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions W93-70255

**E****EARTH (PLANET)**

Planetary Materials: Mineralogy and Petrology W93-70141  
Planetary Materials: Chemistry W93-70144  
Process Studies: Radiation Dynamics and Hydrology, Radiation and Dynamic Processes W93-70308  
Global Change W93-70475

**EARTH ATMOSPHERE**

Atmospheric Effects W93-70052  
4D Data Assimilation for EOS W93-70275  
EOS Science W93-70281  
MM and Sub-MM Radiometry W93-70369  
Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements W93-70381  
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling W93-70441  
Image Processing Laboratory for Terrestrial Ecology W93-70464  
Global Change W93-70475

**EARTH CORE**

Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328

Modeling of the Main Magnetic Field  
579-31-02 W93-70457

Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

Core-Mantle Excitation  
579-36-11 W93-70463

**EARTH CRUST**

Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388

Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389

Dynamics of North American-Pacific Shear  
465-13-02 W93-70390

GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391

Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
465-13-06 W93-70392

Parkfield GPS Experiment  
465-13-08 W93-70393

Global Tectonic Motions  
465-14-01 W93-70394

Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395

Goldstone DOSE Support  
465-28-02 W93-70403

Advanced Magnetometer  
465-31-01 W93-70404

Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405

Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409

Problems in Interpreting Satellite Crustal Anomaly Field Data  
579-31-01 W93-70456

Modeling of the Main Magnetic Field  
579-31-02 W93-70457

Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459

Earth Rotation and Mantle Structure  
579-36-03 W93-70460

**EARTH GRAVITATION**

Electronic Materials  
674-21-08 W93-70506

**EARTH HYDROSPHERE**

Hydrospheric Processes Program Support for Modeling and Data Analysis  
578-97-12 W93-70446

**EARTH IONOSPHERE**

Sounding Rockets: Space Plasma Physics Experiments  
435-11-00 W93-70298

**EARTH MAGNETOSPHERE**

Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178

Sounding Rockets: Space Plasma Physics Experiments  
435-11-00 W93-70298

**EARTH MANTLE**

Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399

Lateral Variations in Solid Tides  
465-17-04 W93-70401

Modeling of the Main Magnetic Field  
579-31-02 W93-70457

Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

Core-Mantle Excitation  
579-36-11 W93-70463

**EARTH OBSERVATIONS (FROM SPACE)**

Observatory Systems  
582-04-00 W93-70114

Automated Geophysical Processor Development for the Alaska SAR Facility  
428-82-11 W93-70273

Thermal Infrared Science Support  
462-75-74 W93-70352

**EARTH OBSERVING SYSTEM (EOS)**

Information and Controls Research and Technology  
506-59-00 W93-70089

Science Sensing (Remote)  
582-03-00 W93-70113

Observatory Systems  
582-04-00 W93-70115

A 4D Data Assimilation for EOS Computer Support  
428-81-04 W93-70262

**Role of Air-Sea Exchanges and Ocean Circulation**

(Computing)  
428-81-10 W93-70263

Global Hydrologic Cycle  
428-81-16 W93-70264

Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267

Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274

Interannual Variability of Global Cycles  
429-81-06 W93-70276

Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277

Global Hydrologic Cycle  
429-81-16 W93-70278

EOS IDS, Stratospheric Temperature and Trace Gas Trends  
429-81-36 W93-70280

EOS Science  
429-81-38 W93-70281

Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282

Project to Interface Modeling  
429-81-72 W93-70283

IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284

Global Assessment of Active Volcanism  
429-81-94 W93-70285

Global Assessment of Active Volcanism  
429-81-95 W93-70286

Global Assessment of Active Volcanism  
429-81-96 W93-70287

Global Assessment of Active Volcanism  
429-81-97 W93-70288

Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289

Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338

ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406

Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413

Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429

Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432

Active/Passive Sea Ice Analysis  
578-32-24 W93-70437

Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440

**EARTH ORBITAL ENVIRONMENTS**

Materials and Structures Research and Technology  
506-43-00 W93-70073

Space Communications Research and Technology  
506-72-00 W93-70098

**EARTH ORBITS**

Space Energy Conversion Research and Technology  
506-41-00 W93-70064

Propulsion Research and Technology  
506-42-00 W93-70068

Materials and Structures Research and Technology  
506-43-00 W93-70077

Space Flight Research and Technology  
506-48-00 W93-70078

Space Flight Research and Technology  
506-48-00 W93-70079

Information and Controls Research and Technology  
506-59-00 W93-70089

Space Communications Research and Technology  
506-72-00 W93-70099

Space Data Systems  
586-03-00 W93-70136

Optical Communications  
310-20-35 W93-70533

**EARTH ORIENTATION**

Global Tectonic Motions  
465-14-01 W93-70394

Geopotential Temporal Variations  
465-17-02 W93-70400

Earth Rotation and Mantle Structure  
579-36-03 W93-70460

Rapid Earth Orientation Changes  
579-36-10 W93-70462

GPS-Based DSN Calibration System  
310-10-61 W93-70530

**EARTH PLANETARY STRUCTURE**

Geopotential Temporal Variations  
465-17-02 W93-70400

Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

**EARTH RADIATION BUDGET**

Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316

Hydrologic Processes, Field Study  
461-10-00 W93-70318

Heterogeneous Scene Models  
462-61-03 W93-70347

**EARTH RADIATION BUDGET EXPERIMENT**

Experimental Cloud Analysis Techniques  
578-12-01 W93-70424

**EARTH RESOURCES**

Automated Geophysical Processor Development for the Alaska SAR Facility  
428-82-11 W93-70273

Thermal Infrared Science Support  
462-75-74 W93-70352

Active/Passive Sea Ice Analysis  
578-32-24 W93-70437

Radar-Altimeter Ice Data System  
578-97-20 W93-70448

**EARTH ROTATION**

Geopotential Temporal Variations  
465-17-02 W93-70400

Lateral Variations in Solid Tides  
465-17-04 W93-70401

Earth Rotation and Mantle Structure  
579-36-03 W93-70460

Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

Rapid Earth Orientation Changes  
579-36-10 W93-70462

Core-Mantle Excitation  
579-36-11 W93-70463

GPS-Based DSN Calibration System  
310-10-61 W93-70530

**EARTH SCIENCES**

Earth and Space Sciences  
509-20-00 W93-70032

Earth and Space Sciences  
509-20-00 W93-70033

Earth and Space Sciences  
509-20-00 W93-70034

Earth and Space Sciences  
509-20-00 W93-70035

Systems Analysis  
506-49-00 W93-70085

Information and Controls Research and Technology  
506-59-00 W93-70090

Observatory Systems  
582-04-00 W93-70115

Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317

Graduate Fellowships  
578-97-16 W93-70447

Bibliography for Land Processes Publications  
579-82-00 W93-70473

Windows on Global Change  
665-82-03 W93-70503

**EARTH SURFACE**

Global Hydrologic Cycle  
428-81-16 W93-70264

4D Data Assimilation for EOS  
429-81-04 W93-70275

Global Hydrologic Cycle  
429-81-16 W93-70278

Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317

Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321

Desert Mesoscale/PBL  
461-13-02 W93-70322

Land Surface Climatology: HAPEX  
462-32-00 W93-70340

Heterogeneous Scene Models  
462-61-03 W93-70347

Airborne Science Management Operating Working Group Support  
462-79-00 W93-70354

Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359

Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418

Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464

Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470

Global Change  
579-97-00 W93-70475

**EARTH TERMINALS**

Space Communications Research and Technology  
506-72-00 W93-70096

# EARTH TIDES

## EARTH TIDES

- Geopotential Temporal Variations W93-70400
- 465-17-02
- Lateral Variations in Solid Tides W93-70401
- 465-17-04
- Ocean Circulation from Satellite Altimetry W93-70431
- 578-22-24

## EARTHQUAKES

- Monitoring Global Sea Level with Altimeter Transponders W93-70328
- 461-38-02
- Crustal Strain Modeling Using Finite Element Methods W93-70388
- 465-12-03
- Modeling of Convergent Plate Margin Deformation W93-70389
- 465-12-06
- GPS Strain Monitoring in the New Madrid Seismic Zone W93-70391
- 465-13-05
- Parkfield GPS Experiment W93-70393
- 465-13-08
- Kinematic Models Combining VLBI, GPS, and Triangulation Data and Plate Constraints W93-70395
- 465-14-07
- Crustal Dynamics Data Information System (CDDIS) W93-70459
- 579-32-06
- Core-Mantle Excitation W93-70463
- 579-36-11

## ECOLOGY

- Biosphere Atmospheric Interactions W93-70265
- 428-81-26
- Biosphere Atmospheric Interactions W93-70279
- 429-81-26
- Image Processing Laboratory for Terrestrial Ecology W93-70464
- 579-41-00
- Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data W93-70493
- 656-65-22

## ECONOMIC ANALYSIS

- Systems Analysis W93-70019
- 505-69-00
- Atmospheric Effects W93-70049
- 537-01-00

## ECONOMIC IMPACT

- Atmospheric Effects W93-70051
- 537-01-00

## ECOSYSTEMS

- Human Support Research and Technology W93-70093
- 506-71-00
- Controlled Ecological Life Support Systems (CELSS) Project W93-70253
- 199-61-11
- Bioregenerative Life Support Research (CELSS) W93-70254
- 199-61-12
- Forest/Climate Interactions W93-70337
- 462-21-00
- Satellite Radar for Forest Structure W93-70343
- 462-41-61
- Biogeochemical Cycling Research on the Oregon Transect W93-70344
- 462-43-00
- Biogeochemical Research in Temperate Ecosystems W93-70345
- 462-43-00
- Visiting Scientists W93-70353
- 462-76-49
- Regional Carbon Flux in High Latitude Ecosystems W93-70359
- 463-43-00
- Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production W93-70361
- 463-61-00
- Biogeochemical Research in Temperate Ecosystems W93-70363
- 463-67-00
- ERS-1 Studies of Forest Ecosystems W93-70466
- 579-41-08
- ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems W93-70499
- 665-35-00

## EDUCATION

- Hypersonic Training and Research W93-70021
- 505-70-00
- Interdisciplinary Technology W93-70024
- 505-90-00
- Interdisciplinary Technology W93-70025
- 505-90-00
- Interdisciplinary Technology W93-70026
- 505-90-00
- Interdisciplinary Technology W93-70027
- 505-90-00
- Planetary Materials: Collection, Preservation and Distribution W93-70149
- 152-20-40
- Behavior, Performance and Human Factors W93-70231
- 199-06-12
- Graduate Fellowships W93-70447
- 578-97-16

- Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives W93-70490
- 656-65-06
- Windows on Global Change W93-70503
- 665-82-03
- Software Engineering Technology W93-70527
- 310-10-23
- DSN Data Processing and Productivity W93-70551
- 310-40-73

## EFFLUENTS

- In-Space Technology Experiments W93-70107
- 506-74-00

## EIGENVECTORS

- Core-Mantle Excitation W93-70463
- 579-36-11

## EJECTORS

- Propulsion and Power Research and Technology W93-70004
- 505-62-00

## EL NINO

- 4D Data Assimilation for EOS W93-70275
- 429-81-04
- An Integrated Study of Surface Property Variations W93-70425
- 578-12-02
- Remote Sensing of Air-Sea Fluxes W93-70426
- 578-12-19
- Tropical Ocean Circulation from Altimetry and Numerical Modeling W93-70430
- 578-21-12

## ELASTIC PROPERTIES

- Emissions and Source Noise W93-70055
- 537-02-00
- Upper Mantle Seismic P and S Wave Study W93-70399
- 465-16-01
- Lateral Variations in Solid Tides W93-70401
- 465-17-04

## ELECTRIC ARCS

- Aerothermodynamics Research and Technology W93-70062
- 506-40-00

## ELECTRIC BATTERIES

- Space Energy Conversion Research and Technology W93-70067
- 506-41-00
- Automation and Robotics W93-70128
- 586-02-00

## ELECTRIC CONTACTS

- Thermal Infrared Science Support W93-70352
- 462-75-74
- Biotechnology Research W93-70508
- 674-23-01

## ELECTRIC DISCHARGES

- Planetary Lightning and Analysis of Voyager Observations W93-70160
- 154-90-80

## ELECTRIC ENERGY STORAGE

- Space Energy Conversion Research and Technology W93-70064
- 506-41-00

## ELECTRIC FIELDS

- Thermosphere-Ionosphere-Mesosphere-Magnetosphere e Interactions W93-70294
- 432-48-00
- Sounding Rockets: Space Plasma Physics Experiments W93-70298
- 435-11-00

## ELECTRIC POTENTIAL

- Gamma-Ray Spectroscopy W93-70208
- 188-46-58

## ELECTRIC PROPULSION

- Space Energy Conversion Research and Technology W93-70067
- 506-41-00

## ELECTRICAL MEASUREMENT

- Gamma-Ray Spectroscopy W93-70208
- 188-46-58

## ELECTRICAL RESISTIVITY

- Geomagnetic Modeling of Core Fluid Motions W93-70458
- 579-31-07

## ELECTRO-OPTICS

- Fly-By-Light/Power-By-Wire Technology W93-70059
- 538-01-00
- Fly-By-Light/Power-By-Wire W93-70060
- 538-01-00

## ELECTROCHEMICAL CELLS

- Space Energy Conversion Research and Technology W93-70064
- 506-41-00
- Space Energy Conversion Research and Technology W93-70067
- 506-41-00
- In-Space Technology Experiments W93-70107
- 506-74-00

## ELECTROCHEMISTRY

- Space Energy Conversion Research and Technology W93-70065
- 506-41-00

## ELECTRODELESS DISCHARGES

- Advanced Magnetometer W93-70404
- 465-31-01

## ELECTRODES

- Propulsion Research and Technology W93-70070
- 506-42-00

## ELECTRODYNAMICS

- Sounding Rockets: Space Plasma Physics Experiments W93-70298
- 435-11-00

## ELECTROKINETICS

- Fluid Physics W93-70512
- 674-24-08

## ELECTROLYSIS

- In-Space Technology Experiments W93-70107
- 506-74-00

## ELECTROLYTES

- In-Space Technology Experiments W93-70107
- 506-74-00

## ELECTROLYTIC CELLS

- In-Space Technology Experiments W93-70107
- 506-74-00

## ELECTROMAGNETIC COUPLING

- Magnetospheric Coupling W93-70293
- 432-36-00

## ELECTROMAGNETIC INTERFERENCE

- Fly-By-Light/Power-By-Wire W93-70060
- 538-01-00

## ELECTROMAGNETIC RADIATION

- Planetary Materials: Surface and Exposure Studies W93-70147
- 152-17-40
- Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions W93-70294
- 432-48-00
- Sounding Rockets: Space Plasma Physics Experiments W93-70298
- 435-11-00

## ELECTROMAGNETIC SCATTERING

- Scatterometer Research W93-70323
- 461-31-09

## ELECTROMAGNETIC SPECTRA

- Theory, Laboratory and Data Analysis for Solar Physics W93-70180
- 170-38-53
- AVIRIS Operations W93-70417
- 465-65-01

## ELECTROMECHANICAL DEVICES

- Fly-By-Light/Power-By-Wire Technology W93-70059
- 538-01-00
- Fly-By-Light/Power-By-Wire W93-70060
- 538-01-00

## ELECTRON BEAMS

- Space Communications Research and Technology W93-70096
- 506-72-00
- Solar Physics Studies W93-70181
- 170-38-53

## ELECTRON DENSITY (CONCENTRATION)

- Solar Physics Studies W93-70181
- 170-38-53
- SPARTAN 201 White Light Coronagraph W93-70521
- 879-10-00

## ELECTRON ENERGY

- Neptune Data Analysis W93-70524
- 889-59-00

## ELECTRON ENERGY

- Solar Physics Studies W93-70181
- 170-38-53
- Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals W93-70190
- 188-41-57

## ELECTRON DENSITY (CONCENTRATION)

- Solar Physics Studies W93-70181
- 170-38-53
- SPARTAN 201 White Light Coronagraph W93-70521
- 879-10-00

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- 170-38-53
- SPARTAN 201 White Light Coronagraph W93-70521
- 879-10-00

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- Neptune Data Analysis W93-70524
- 889-59-00

## ELECTRON ENERGY

- Solar Physics Studies W93-70181
- 170-38-53
- Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals W93-70190
- 188-41-57

## ELECTRON ENERGY

- Optical/UV Laboratory Astrophysics W93-70191
- 188-41-57
- Thermosphere-Ionosphere-Mesosphere-Magnetosphere e Interactions W93-70294
- 432-48-00

## ELECTRON ENERGY

- SPARTAN 201 White Light Coronagraph W93-70521
- 879-10-00
- Sounding Rocket Experiments W93-70522
- 879-11-38

## ELECTRON IMPACT

- Optical/UV Laboratory Astrophysics W93-70191
- 188-41-57

## ELECTRON MICROSCOPES

- Planetary Materials: Mineralogy and Petrology W93-70141
- 152-11-40

## ELECTRON MICROSCOPY

- A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains W93-70143
- 152-12-40
- Planetary Materials: Surface and Exposure Studies W93-70147
- 152-17-40

## ELECTRON PARAMAGNETIC RESONANCE

- Space Radiation W93-70228
- 199-04-14

## ELECTRON PROBES

- Planetary Materials: Mineralogy and Petrology W93-70141
- 152-11-40



**ELECTRON SCATTERING**

Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)  
188-46-01 W93-70204

**ELECTRON TRANSITIONS**

Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180  
Submillimeter Astronomy  
188-44-23 W93-70194

**ELECTRON-POSITRON PAIRS**

Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)  
188-46-01 W93-70204

**ELECTRONIC EQUIPMENT**

Electronic Materials  
674-21-05 W93-70505

**ELECTRONICS**

Stratospheric Observatory for Infrared Astronomy (SOFIA)  
188-78-60 W93-70216

**ELECTRONS**

Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Solar Physics Studies  
170-38-53 W93-70181  
X-Ray Astronomy CCD  
188-46-59 W93-70209  
Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226

**ELECTROSTATICS**

Propulsion Research and Technology  
506-42-00 W93-70070

**ELECTROTHERMAL ENGINES**

Propulsion Research and Technology  
506-42-00 W93-70070

**ELEVATION**

Radar-Altitude Ice Data System  
578-97-20 W93-70448

**ELEVATION ANGLE**

Microwave Temperature Profiler  
464-14-20 W93-70374

**EMBEDDING**

Expert Systems for Automation of Operations  
310-40-47 W93-70547  
DSN Data Processing and Productivity  
310-40-73 W93-70551

**EMERGENCIES**

Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**EMISSION SPECTRA**

Laboratory Astrophysics  
188-44-57 W93-70201  
Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361  
Airborne IR Spectrometry  
464-12-00 W93-70367  
Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370  
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383  
Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457  
Sounding Rocket Experiments  
879-11-38 W93-70522

**EMISSIVITY**

Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196

**EMULSIONS**

In-Space Technology Experiments  
506-74-00 W93-70106

**END EFFECTORS**

Automation and Robotics  
586-02-00 W93-70133

**END-TO-END DATA SYSTEMS**

DSN Data Processing and Productivity  
310-40-73 W93-70551

**ENDOCRINOLOGY**

Regulatory Physiology (Biomedical)  
199-18-12 W93-70235

**ENERGETIC PARTICLES**

Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies  
188-46-01 W93-70205  
Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions  
432-48-00 W93-70294

Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298

**ENERGY BUDGETS**

Properties of Interstellar PAH's  
188-44-57 W93-70202  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
428-81-10 W93-70263  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277  
EOS Science  
429-81-38 W93-70281  
Global Assessment of Active Volcanism  
429-81-94 W93-70285  
GEWEX Program Support  
461-50-03 W93-70331  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
578-40-00 W93-70441  
Neptune Data Analysis Program  
889-59-00 W93-70526

**ENERGY CONSUMPTION**

Information and Communications  
586-03-00 W93-70137

**ENERGY CONVERSION**

Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Space Energy Conversion Research and Technology  
506-41-00 W93-70065  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067  
Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180

**ENERGY CONVERSION EFFICIENCY**

GA/Commuter Engine Technology  
535-05-00 W93-70046  
Surface Systems  
583-02-00 W93-70117  
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339

**ENERGY DISSIPATION**

Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
Sounding Rocket Experiments  
879-11-38 W93-70522  
Neptune Data Analysis  
889-59-00 W93-70525

**ENERGY LEVELS**

Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Laboratory Astrophysics  
188-44-57 W93-70203

**ENERGY POLICY**

Space Energy Conversion Research and Technology  
506-41-00 W93-70066

**ENERGY SPECTRA**

Spectral and Physical Properties of Planetary Atmospheric Constituents  
154-50-80 W93-70156  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176

**ENERGY STORAGE**

Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Space Flight Research and Technology  
506-48-00 W93-70078  
Space Flight Research and Technology  
506-48-00 W93-70080  
Automation and Robotics  
586-02-00 W93-70128

**ENERGY TRANSFER**

Materials and Structures Research and Technology  
506-43-00 W93-70076  
Spectral and Physical Properties of Planetary Atmospheric Constituents  
154-50-80 W93-70156  
Space Radiation  
199-04-14 W93-70228

Interannual Variability of Global Cycles  
429-81-06 W93-70276  
Biosphere Atmospheric Interactions  
429-81-26 W93-70279  
EOS Science  
429-81-38 W93-70281  
Magnetospheric Coupling  
432-36-00 W93-70293  
Altitude Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Sounding Rocket Experiments  
879-11-38 W93-70522

**ENGINE AIRFRAME INTEGRATION**

Propulsion and Power  
505-62-00 W93-70005  
Systems Analysis  
505-69-00 W93-70018  
Systems Analysis  
505-69-00 W93-70019  
Atmospheric Effects  
537-01-00 W93-70049  
Emissions and Source Noise  
537-02-00 W93-70053

**ENGINE DESIGN**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
GA/Commuter Engine Technology  
535-05-00 W93-70046  
Earth-to-Orbit Transportation  
584-03-00 W93-70118

**ENGINE FAILURE**

Information and Controls Research and Technology  
506-59-00 W93-70088

**ENGINE INLETS**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Emissions and Source Noise  
537-02-00 W93-70053

**ENGINE NOISE**

Atmospheric Effects  
537-01-00 W93-70051  
Community Noise and Sonic Boom  
537-03-00 W93-70056

**ENGINE PARTS**

Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
Computational Aerodynamics  
509-10-00 W93-70030  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
Emissions and Source Noise  
537-02-00 W93-70054  
Enabling Propulsion Materials  
537-04-00 W93-70058

**ENGINE TESTS**

High-Performance Flight Research  
533-02-00 W93-70041  
Propulsion Research and Technology  
506-42-00 W93-70070

**ENGINEERING MANAGEMENT**

DSN Data Processing and Productivity  
310-40-73 W93-70551

**ENVIRONMENT EFFECTS**

Advanced Composite Materials Technology  
510-02-00 W93-70037  
Atmospheric Effects  
537-01-00 W93-70050  
Space Flight Research and Technology  
506-48-00 W93-70078  
In-Space Technology Experiments  
506-74-00 W93-70106  
Behavior, Performance and Human Factors  
199-06-12 W93-70231  
Cell and Development Biology  
199-40-21 W93-70239  
EOS IDS, EOSDIS Money  
428-81-36 W93-70266  
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339  
MM and Sub-MM Radiometry  
464-12-06 W93-70369

**ENVIRONMENT MODELS**

Biogeochemical Cycling Research on the Oregon Transect  
462-43-00 W93-70344

## ENVIRONMENT SIMULATION

- Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345  
Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363  
Global Climate Modeling  
578-41-01 W93-70442

## ENVIRONMENTAL SIMULATION

- Mars Surface and Atmosphere Studies  
155-04-00 W93-70162

## ENVIRONMENTAL LABORATORIES

- Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517

## ENVIRONMENTAL MONITORING

- Human Support Research and Technology  
506-71-00 W93-70093  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496  
Optical Communications Technology Development  
310-20-67 W93-70541

## ENVIRONMENTAL SURVEYS

- Micro Weather Stations for Mars  
157-04-80 W93-70174

## ENVIRONMENTAL TESTS

- In-Space Technology Experiments  
506-74-00 W93-70106

## EPIDERMIS

- Cell and Developmental Biology  
199-40-22 W93-70240

## EPITAXY

- Science Sensing (Remote)  
582-03-00 W93-70109  
Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188

## EQUINOXES

- Theory of Geodetic Transformations  
465-15-06 W93-70398

## EQUIVALENCE

- Fluid Physics  
674-24-08 W93-70512

## EROSION

- Materials and Structures Research and Technology  
506-43-00 W93-70073  
Materials and Structures Research and Technology  
506-43-00 W93-70075

## ERROR ANALYSIS

- Automation and Robotics  
586-02-00 W93-70127  
Automation and Robotics  
586-02-00 W93-70131  
Study of Potential Mars Observer - Mars 94, 96 Flight  
Path Cooperatives  
152-88-10 W93-70151  
Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Parkfield GPS Experiment  
465-13-08 W93-70393  
Global Tectonic Motions  
465-14-01 W93-70394  
North American Fiducial Network  
465-14-11 W93-70397  
Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402  
Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457  
ASF SAR Interferometry  
665-35-01 W93-70500  
Astrometric Development Technology  
310-10-60 W93-70529  
GPS-Based DSN Calibration System  
310-10-61 W93-70530  
Space Systems and Navigation Technology  
310-10-63 W93-70532

## ERROR SIGNALS

- Network Signal Processing  
310-30-70 W93-70543

## ERRORS

- Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430

## ESA SATELLITES

- HIPPARCOS VLBI  
399-18-00 W93-70256

## ESA SPACECRAFT

- High Energy Astrophysics International Programs  
440-62-59 W93-70299

## ESTIMATES

- Global Assessment of Active Volcanism  
428-81-96 W93-70270  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425  
ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

## ESTIMATING

- Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Problems in Interpreting Satellite Crustal Anomaly Field  
Data  
579-31-01 W93-70456

## ETALONS

- Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

## ETHANE

- Ground-Based Infrared Astronomy  
196-41-50 W93-70218

## EUKARYOTES

- The Early Evolution of Life  
199-52-32 W93-70248

## EUROPE

- Global Tectonic Motions  
465-14-01 W93-70394

## EUROPEAN SPACE AGENCY

- Integral Mission Definition Study  
188-78-01 W93-70211  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
Oceanic Remote Sensing Library  
461-66-16 W93-70335  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate  
578-35-02 W93-70439  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

## EVALUATION

- Consulting and Program Support  
674-29-08 W93-70520

## EVAPORATION

- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426

## EVAPOTRANSPIRATION

- Forest/Climate Interactions  
462-21-00 W93-70337  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342

## EXCIMER LASERS

- Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals  
188-41-57 W93-70190  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371

## EXCITATION

- Solar Physics Studies  
170-38-53 W93-70181  
Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals  
188-41-57 W93-70190

## EXHAUST EMISSION

- Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362

## EXHAUST GASES

- Biospheric/Atmospheric Interactions  
463-67-00 W93-70362  
Measurement of Volcanic Gases  
465-44-05 W93-70414

## EXHAUST NOZZLES

- Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Propulsion and Power  
505-62-00 W93-70005  
Enabling Propulsion Materials  
537-04-00 W93-70058

## EXHAUST SYSTEMS

- Propulsion and Power  
505-62-00 W93-70005

## EXOBIOLGY

- Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226  
Space Radiation  
199-04-14 W93-70228  
Space Human Factors Behavior and Performance  
199-06-11 W93-70229  
General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232  
Neuroscience (Biomedical)  
199-16-12 W93-70234  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237  
Cell and Development Biology  
199-40-21 W93-70239  
Cell and Developmental Biology  
199-40-22 W93-70240  
Integrative Biology  
199-40-32 W93-70241  
Structural Biosystems  
199-40-42 W93-70242  
Flight Research  
199-40-72 W93-70244  
Exobiology Intact Capture Technology Development  
199-52-54 W93-70250  
Exploration Exobiology  
199-52-82 W93-70251

## EXOSKELETONS

- Automation and Robotics  
586-02-00 W93-70130

## EXOSPHERE

- Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217  
Thermosphere-Ionosphere-Mesosphere-Magnetospher  
e Interactions  
432-48-00 W93-70294

## EXPERIMENT DESIGN

- Laboratory Astrophysics  
188-44-57 W93-70201  
Fluid Physics  
674-24-05 W93-70511

## EXPERIMENTATION

- Flight Research  
199-40-62 W93-70243

## EXPERT SYSTEMS

- Controls, Guidance, and Human Factors Research and  
Technology  
505-64-00 W93-70010  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Human Support Research and Technology  
506-71-00 W93-70093  
Automation and Robotics  
586-02-00 W93-70127  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70129  
Automation and Robotics  
586-02-00 W93-70131  
DataHub - Knowledge-Based Assistance for Science  
Visualization and Analysis Using Large Distributed  
Databases  
656-65-21 W93-70492  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534  
Mission Operations Technology  
310-40-45 W93-70546  
Expert Systems for Automation of Operations  
310-40-47 W93-70547  
DSN Data Processing and Productivity  
310-40-73 W93-70551

## EXPOSURE

- Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225

**EXTINCTION**  
Microgravity Nucleation and Particle Coagulation Experiments  
152-20-01 W93-70148

**EXTRAGALACTIC RADIO SOURCES**  
Infrared/Radio Research  
188-44-21 W93-70193  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196

**EXTRATERRESTRIAL LIFE**  
Exploration Exobiology  
199-52-82 W93-70251

**EXTRATERRESTRIAL RADIATION**  
Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226  
Space Radiation  
199-04-14 W93-70228

**EXTRAVEHICULAR ACTIVITY**  
Human Support Research and Technology  
506-71-00 W93-70093  
Regulatory Physiology (Biomedical)  
199-18-12 W93-70235

**EXTREME ULTRAVIOLET EXPLORER SATELLITE**  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191

**EXTREME ULTRAVIOLET RADIATION**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Sounding Rocket Experiments  
879-11-38 W93-70522

**EXTREMELY HIGH FREQUENCIES**  
Space Communications Research and Technology  
506-72-00 W93-70099  
Frequency and Timing Research  
310-10-62 W93-70531  
Advanced Transmitter Systems Development  
310-20-64 W93-70538  
Radio Systems Development  
310-20-66 W93-70540  
Network Signal Processing  
310-30-70 W93-70543

**EYE MOVEMENTS**  
Neuroscience (Biomedical)  
199-16-12 W93-70234

**F**

**F-15 AIRCRAFT**  
High-Performance Flight Research  
533-02-00 W93-70041

**F-16 AIRCRAFT**  
High-Performance Flight Research  
533-02-00 W93-70041  
Community Noise and Sonic Boom  
537-03-00 W93-70056

**F-18 AIRCRAFT**  
High-Performance Flight Research  
533-02-00 W93-70041  
High Performance Flight Research  
533-02-00 W93-70042

**FABRICATION**  
Advanced Composite Materials Technology  
510-02-00 W93-70038  
Materials and Structures Research and Technology  
506-43-00 W93-70075  
Space Flight Research and Technology  
506-48-00 W93-70081  
Human Support Research and Technology  
506-71-00 W93-70093  
Astrometric Imaging Telescope  
157-03-70 W93-70171  
Solar Probe ATD  
433-06-00 W93-70296  
Optical Communications Technology Development  
310-20-67 W93-70541

**FABRY-PEROT SPECTROMETERS**  
Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370

**FAILURE**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036

**FAILURE ANALYSIS**  
Materials and Structures Research and Technology  
505-63-00 W93-70009  
Enabling Propulsion Materials  
537-04-00 W93-70058  
Information and Controls Research and Technology  
506-59-00 W93-70092

**FAILURE MODES**  
Advanced Composite Materials Technology  
510-02-00 W93-70037

Data Storage Technology  
310-40-48 W93-70548

**FAR INFRARED RADIATION**  
Science Sensing (Remote)  
582-03-00 W93-70109  
Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers  
157-05-50 W93-70175  
Optical Technology for Space Astronomy  
188-41-23 W93-70186  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Laboratory Astrophysics  
188-44-57 W93-70201  
The Nature of Interstellar Dust, Ices and Polycyclic Aromatic Hydrocarbons  
399-50-00 W93-70261  
Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370

**FAR ULTRAVIOLET RADIATION**  
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
The Nature of Interstellar Dust, Ices and Polycyclic Aromatic Hydrocarbons  
399-50-00 W93-70261

**FAR UV SPECTROSCOPIC EXPLORER**  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191

**FARM CROPS**  
ECHOVAL Field Experiment in Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Soil Moisture from SAR  
462-62-05 W93-70349

**FATIGUE (MATERIALS)**  
Aging Aircraft  
538-02-00 W93-70061

**FATIGUE LIFE**  
Advanced Composite Materials Technology  
510-02-00 W93-70037

**FAULT TOLERANCE**  
Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70011  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Information and Communications  
586-02-00 W93-70134  
Information and Communications  
586-03-00 W93-70137  
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495

**FEASIBILITY ANALYSIS**  
Integral Mission Definition Study  
188-78-01 W93-70211

**FEED SYSTEMS**  
Earth-to-Orbit Transportation  
584-03-00 W93-70121

**FEEDBACK**  
EOS IDS, EOSDIS Money  
428-81-36 W93-70266

**FEEDBACK CONTROL**  
Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059  
Human Support Research and Technology  
506-71-00 W93-70093  
Earth-Orbiting Platforms  
585-03-00 W93-70125

**FERTILITY**  
Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361

**FIBER OPTICS**  
Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Information and Communications  
586-03-00 W93-70135  
Advanced Magnetometer  
465-31-01 W93-70404  
Frequency and Timing Research  
310-10-62 W93-70531

Networks Communication Technology  
310-20-38 W93-70536

**FIELD EFFECT TRANSISTORS**  
Science Sensing (Remote)  
582-03-00 W93-70109

**FIELD OF VIEW**  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521

**FIGHTER AIRCRAFT**  
Aerodynamics Research and Technology  
505-59-00 W93-70002  
Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Propulsion and Power  
505-62-00 W93-70005  
Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010  
Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70011  
Flight Systems Research and Technology  
505-68-00 W93-70014  
Flight Systems Research and Technology  
505-68-00 W93-70015  
Systems Analysis  
505-69-00 W93-70019  
Advanced Turboprop Systems  
535-03-00 W93-70045

**FILE MAINTENANCE (COMPUTERS)**  
LTP Computer Support  
579-41-04 W93-70465

**FINANCE**  
Management Support: Origins of Solar Systems Research Program  
452-89-91 W93-70307

**FINITE DIFFERENCE THEORY**  
Dynamics of Planetary Atmospheres  
154-20-80 W93-70153  
Windows on Global Change  
665-82-03 W93-70503

**FINITE ELEMENT METHOD**  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389

**FIRE PREVENTION**  
In-Space Technology Experiments  
506-74-00 W93-70103  
Combustion Science  
674-22-05 W93-70507

**FIRE**  
In-Space Technology Experiments  
506-74-00 W93-70103  
Foreign Visitor Support  
429-97-04 W93-70290  
Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472

**FISSION**  
Propulsion Research and Technology  
506-42-00 W93-70070

**FLAMMABILITY**  
Combustion Science  
674-22-05 W93-70507

**FLASH LAMPS**  
Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals  
154-75-80 W93-70159

**FLEXIBLE SPACECRAFT**  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Earth-Orbiting Platforms  
585-03-00 W93-70126

**FLIGHT ALTITUDE**  
Atmospheric Effects  
537-01-00 W93-70052

**FLIGHT CHARACTERISTICS**  
Propulsion and Power Research and Technology  
505-62-00 W93-70004  
High-Performance Flight Research  
533-02-00 W93-70041  
Space Flight Research and Technology  
506-48-00 W93-70081  
Science Sensing (Remote)  
582-03-00 W93-70110  
Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317

**FLIGHT CONDITIONS**  
Space Human Factors Behavior and Performance  
199-06-11 W93-70229

**FLIGHT CONTROL**  
Flight Systems Research and Technology  
505-68-00 W93-70013

# FLIGHT CREWS

Flight Systems Research and Technology	W93-70015	Fly-By-Light/Power-By-Wire Technology	W93-70059	Global Assessment of Active Volcanism	W93-70288
505-68-00		538-01-00		429-81-97	
High-Performance Flight Research	W93-70041	Fly-By-Light/Power-By-Wire	W93-70060	Remote Sensing of Active and Recently Active Volcanic	
533-02-00		538-01-00		Features	
Fly-By-Light/Power-By-Wire Technology	W93-70059	Information and Controls Research and Technology	W93-70089	465-44-01	W93-70411
538-01-00		506-59-00		Evolution of Volcanic Terrains	
Fly-By-Light/Power-By-Wire	W93-70060	Earth-Orbiting Platforms	W93-70125	465-44-02	W93-70412
538-01-00		Earth-Orbiting Platforms	W93-70126	Carbon Mass Balance During Soil Evolution Along	
Systems Analysis	W93-70085	585-03-00		Climate Gradients	
506-49-00		585-03-00		465-45-01	W93-70416
Automation and Robotics	W93-70132	U.S. Participating Scientist MARS 94/96 - Mars Global		Modeling of the Main Magnetic Field	
586-02-00		Geodesy	W93-70166	579-31-02	W93-70457
Information and Communications	W93-70135	155-20-02		Fluid Physics	
586-03-00		Gamma-Ray Astronomy and Technology Development	W93-70206	674-24-00	W93-70510
Information and Communications	W93-70137	188-46-57		<b>FLUID MANAGEMENT</b>	
586-03-00		Sounding Rockets: Space Plasma Physics		Propulsion Research and Technology	
<b>FLIGHT CREWS</b>		Experiments	W93-70298	506-42-00	W93-70068
Controls, Guidance, and Human Factors Research and		435-11-00		In-Space Technology Experiments	
Technology	W93-70010	Airborne Precipitation Radar	W93-70332	506-74-00	W93-70103
505-64-00		461-51-16		<b>FLUORESCENCE</b>	
Controls, Guidance and Human Factors Research and		Airborne Interferometric Topography	W93-70350	Biogeochemical Cycling Research on the Oregon	
Technology	W93-70011	462-74-01		Transect	
505-64-00		Airborne Interferometric Topography	W93-70419	462-43-00	W93-70344
<b>FLIGHT ENVELOPES</b>		465-67-04		<b>FLUOROCARBONS</b>	
Computational/ Aeroscience	W93-70031	<b>FLOAT ZONES</b>		Global Tropospheric Modeling of Trace Gases	
509-10-00		Electronic Materials	W93-70506	579-24-06	W93-70454
<b>FLIGHT HAZARDS</b>		674-21-08		<b>FLUTTER</b>	
Controls, Guidance and Human Factors Research and		<b>FLOODS</b>		Materials and Structures Research and Technology	
Technology	W93-70012	A Spatial Analysis and Modeling System for		505-63-00	W93-70006
505-64-00		Environmental Management	W93-70496	<b>FLUTTER ANALYSIS</b>	
<b>FLIGHT INSTRUMENTS</b>		656-65-26		Materials and Structures Research and Technology	
Materials and Structures Research and Technology	W93-70077	<b>FLOW DISTRIBUTION</b>		505-63-00	W93-70006
506-43-00		High Performance Flight Research	W93-70042	<b>FLUX (RATE)</b>	
<b>FLIGHT MANAGEMENT SYSTEMS</b>		533-02-00		Biogeochemical Research in Tropical Ecosystems:	
Controls, Guidance and Human Factors Research and		Emissions and Source Noise	W93-70053	Mechanisms of Trace Gas Production	
Technology	W93-70011	537-02-00		463-61-00	W93-70361
505-64-00		Aerothermodynamics Research and Technology	W93-70063	<b>FLUX DENSITY</b>	
<b>FLIGHT MECHANICS</b>		506-40-00		Theory, Laboratory and Data Analysis for Solar	
Interdisciplinary Technology	W93-70027	Global Assessment of Active Volcanism	W93-70288	Physics	
505-90-00		429-81-97		170-38-53	W93-70180
<b>FLIGHT OPERATIONS</b>		Evolution of Volcanic Terrains	W93-70412	<b>FLYBY MISSIONS</b>	
Earth-to-Orbit Transportation	W93-70118	465-44-02		Mars Atmosphere Dust Opacity	
584-03-00		Geomagnetic Modeling of Core Fluid Motions	W93-70458	155-04-00	W93-70163
Earth-Orbiting Platforms	W93-70124	579-31-07		<b>FLYING PLATFORMS</b>	
585-03-00		DSN Data Processing and Productivity	W93-70551	Stratospheric Processes and Atmospheric Chemistry	
Earth Science Advanced Aircraft (ESAA)	W93-70317	310-40-73		Studies	
460-97-00		<b>FLOW MEASUREMENT</b>		464-14-00	W93-70373
Airborne Science Management Operating Working		Fluid Physics	W93-70510	Global Tropospheric Experiment Aircraft,	
Group Support	W93-70354	674-24-00		Measurements	
462-79-00		<b>FLOW STABILITY</b>		464-54-00	W93-70387
Airborne Science Management Operating Working		Fluid Physics	W93-70511	<b>FOCAL PLANE DEVICES</b>	
Group Support	W93-70418	<b>FLOW VELOCITY</b>		Science Sensing (Remote)	
465-66-00		Convective Transport in the Solar Nebula	W93-70303	582-03-00	W93-70112
Navigation Ancillary Information Facility (NAIF)	W93-70480	452-22-91		Ground-Based Infrared Astronomy	
656-61-05		SPARTAN 201 White Light Coronagraph	W93-70521	196-41-50	W93-70218
Mission Operations Technology	W93-70546	879-10-00		<b>FOOD PRODUCTION (IN SPACE)</b>	
310-40-45		<b>FLUID DYNAMICS</b>		Bioregenerative Life Support Research (CELSS)	
<b>FLIGHT PATHS</b>		Applied Aerodynamics Research and Technology	W93-70001	199-61-12	W93-70254
Community Noise and Sonic Boom	W93-70057	505-59-00		<b>FOREBODIES</b>	
537-03-00		Hypersonic Training and Research	W93-70021	High Performance Flight Research	
Study of Potential Mars Observer - Mars 94, 96 Flight		505-70-00		533-02-00	W93-70042
Path Cooperatives	W93-70151	Advanced Rotorcraft Technology	W93-70039	<b>FORECASTING</b>	
152-88-10		532-06-00		A Spatial Analysis and Modeling System for	
<b>FLIGHT PLANS</b>		High Performance Flight Research	W93-70042	Environmental Management	
Communication Systems Research	W93-70544	533-02-00		656-65-26	W93-70496
310-30-71		In-Space Experiments	W93-70105	<b>FOREST MANAGEMENT</b>	
<b>FLIGHT SAFETY</b>		506-74-00		A Spatial Analysis and Modeling System for	
Cardiopulmonary Physiology	W93-70233	Two-Phase Nebulae	W93-70304	Environmental Management	
199-14-12		452-22-93		656-65-26	W93-70496
<b>FLIGHT SIMULATION</b>		Evolution of Volcanic Terrains	W93-70412	<b>FORESTS</b>	
Controls, Guidance, and Human Factors Research and		465-44-02		Remote Measurement of the Gain of Satellite	
Technology	W93-70010	Validation of Volcanic Plume Models with Remote		Radiometers: The NASA Aircraft Satellite Instrument	
505-64-00		Sensing	W93-70413	Calibration (NASIC) Project	
Flight Systems Research and Technology	W93-70013	465-44-04		428-82-18	W93-70274
505-68-00		Fluid Physics	W93-70511	Foreign Visitor Support	
Advanced Rotorcraft Technology	W93-70039	674-24-05		429-97-04	W93-70290
532-06-00		Fluid Physics	W93-70512	Forest/Climate Interactions	
<b>FLIGHT TESTS</b>		674-24-08		462-21-00	W93-70337
Applied Aerodynamics Research and Technology	W93-70001	Glasses and Ceramics	W93-70516	Satellite Radar for Forest Structure	
505-59-00		674-26-08		462-41-61	W93-70343
Materials and Structures Research and Technology	W93-70006	Ground Experiment Operations	W93-70518	Biogeochemical Cycling Research on the Oregon	
505-63-00		674-28-05		Transect	
Controls, Guidance and Human Factors Research and		<b>FLUID FLOW</b>		462-43-00	W93-70344
Technology	W93-70011	Applied Aerodynamics Research and Technology	W93-70001	Biogeochemical Research in Temperate Ecosystems	
505-64-00		505-59-00		462-43-00	W93-70345
Flight Systems Research and Technology	W93-70013	Hypersonic Training and Research	W93-70021	Radar Scattering Inversion: Forested Areas	
505-68-00		505-70-00		462-62-04	W93-70348
Flight Systems Research and Technology	W93-70014	Aerothermodynamics Research and Technology	W93-70063	Biogeochemical Research in Temperate Ecosystems	
505-68-00		506-40-00		463-67-00	W93-70363
Advanced Rotorcraft Technology	W93-70039	Global Assessment of Active Volcanism	W93-70269	ERS-1 Studies of Forest Ecosystems	
532-06-00		428-81-94		579-41-08	W93-70466
High-Performance Flight Research	W93-70041	Global Assessment of Active Volcanism	W93-70285	Geographical Information System for Fusion and	
533-02-00		429-81-94		Analysis of High-Resolution Remote Sensing and Ground	
Advanced Turboprop Systems	W93-70045	Global Assessment of Active Volcanism	W93-70286	Truth Data	
535-03-00		429-81-95		656-65-22	W93-70493

Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**FORMAT**  
Landsat Land Cover Pathfinder  
579-98-00 W93-70476  
Data Management Initiative - National Space Science  
Data Center  
656-61-21 W93-70487

**FORWARD SCATTERING**  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348

**FOURIER ANALYSIS**  
Theory of Geodetic Transformations  
465-15-06 W93-70398

**FOURIER TRANSFORMATION**  
Laboratory Astrophysics  
188-44-57 W93-70203  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Ground-Based Infrared Astronomy  
196-41-50 W93-70218  
Advanced Infrared Astronomy  
196-41-54 W93-70220  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386  
Measurement of Volcanic Gases  
465-44-05 W93-70414  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523

**FRACTIONATION**  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143  
Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306

**FRACTURE MECHANICS**  
Materials and Structures Research and Technology  
505-63-00 W93-70009  
GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391

**FREE CONVECTION**  
Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303

**FREE FLIGHT**  
Space Flight Research and Technology  
506-48-00 W93-70080

**FREE RADICALS**  
Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386

**FREEZING**  
Solar Physics Studies  
170-38-53 W93-70181

**FREQUENCIES**  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
Polarimetric Data Analysis  
461-64-11 W93-70334  
Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542

**FREQUENCY ASSIGNMENT**  
Optical Communications  
310-20-35 W93-70533

**FREQUENCY DISCRIMINATORS**  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333

**FREQUENCY DISTRIBUTION**  
Space Communications Research and Technology  
506-72-00 W93-70096

**FREQUENCY STABILITY**  
In-Space Technology Experiments  
506-74-00 W93-70106  
Frequency and Timing Research  
310-10-62 W93-70531  
Antenna Systems Development  
310-20-65 W93-70539

**FREQUENCY STANDARDS**  
In-Space Technology Experiments  
506-74-00 W93-70106

Frequency and Timing Research  
310-10-62 W93-70531  
Advanced Transmitter Systems Development  
310-20-64 W93-70538

**FRESH WATER**  
An Ocean General Circulation Model for Climate  
Studies  
578-41-43 W93-70443  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

**FRICTION**  
Materials and Structures Research and Technology  
506-43-00 W93-70073

**FUEL CONSUMPTION**  
Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036

**FUNCTIONAL DESIGN SPECIFICATIONS**  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
Data Interchange Standards  
656-61-03 W93-70479

**FUSELAGES**  
Advanced Composite Materials Technology  
510-02-00 W93-70038  
Aging Aircraft  
538-02-00 W93-70061

## G

**G STARS**  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

**GALACTIC CLUSTERS**  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199

**GALACTIC EVOLUTION**  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246

**GALACTIC NUCLEI**  
Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206

**GALAXIES**  
Deep Optical/UV Imaging of Quasars Below the Lyman  
Limit  
188-41-21 W93-70183  
UV Astronomy and Data Systems  
188-41-51 W93-70189  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206

**GALLIUM ARSENIDES**  
Science Sensing (Remote)  
582-03-00 W93-70109

**GAMMA RAY ASTRONOMY**  
High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Gamma Ray Astronomy  
188-46-57 W93-70207

**GAMMA RAY OBSERVATORY**  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
High Energy Astrophysics International Programs  
440-62-59 W93-70299  
Mission Operations Technology  
310-40-45 W93-70546

**GAMMA RAY SPECTRA**  
Gamma-Ray Spectroscopy  
188-46-58 W93-70208

**GAMMA RAY SPECTROMETERS**  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Instrument Definition and Development  
157-03-50 W93-70169

Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Gamma-Ray Spectroscopy  
188-46-58 W93-70208  
Integral Mission Definition Study  
188-78-01 W93-70211

**GAMMA RAYS**  
Science Sensing (Remote)  
582-03-00 W93-70109  
Science Sensing (Remote)  
582-03-00 W93-70111  
Observatory Systems  
582-04-00 W93-70115  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Gamma Ray Astronomy  
188-46-57 W93-70207  
Gamma-Ray Spectroscopy  
188-46-58 W93-70208  
Integral Mission Definition Study  
188-78-01 W93-70211  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523

**GAS ANALYSIS**  
Atmospheric Effects  
537-01-00 W93-70049  
Science Sensing (Remote)  
582-03-00 W93-70110  
Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156  
Measurement of Volcanic Gases  
465-44-05 W93-70414

**GAS CHROMATOGRAPHY**  
Space Data Systems  
586-03-00 W93-70136  
Solar System Exploration  
199-52-52 W93-70249

**GAS COMPOSITION**  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371

**GAS DETECTORS**  
Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156

**GAS EVOLUTION**  
Laboratory Astrophysics  
188-44-57 W93-70201

**GAS EXCHANGE**  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362

**GAS FLOW**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062

**GAS GIANT PLANETS**  
Dynamical Properties of Planetary Atmospheres  
154-20-80 W93-70154  
Advanced Infrared Astronomy  
196-41-54 W93-70220

**GAS MIXTURES**  
Chemical Kinetics and Spectroscopy of Planetary  
Molecules and Radicals  
154-75-80 W93-70159  
Solar System Exploration  
199-52-52 W93-70249  
EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280

**GAS SPECTROSCOPY**  
Biogeochemical Research in Tropical Ecosystems:  
Mechanisms of Trace Gas Production  
463-61-00 W93-70361

**GAS TRANSPORT**  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

**GAS TURBINE ENGINES**  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
GA/Commuter Engine Technology  
535-05-00 W93-70046  
Enabling Propulsion Materials  
537-04-00 W93-70058

**GAS-SOLID INTERACTIONS**  
Materials and Structures Research and Technology  
506-43-00 W93-70071

**GASES**  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

**GENE EXPRESSION**

Space Radiation W93-70228  
199-04-14

**GENERAL AVIATION AIRCRAFT**

Propulsion and Power Research and Technology W93-70004  
505-62-00  
Materials and Structures Research and Technology W93-70009  
505-63-00  
GA/Commuter Engine Technology W93-70046  
535-05-00

**GENES**

Space Radiation W93-70228  
199-04-14

**GENETIC CODE**

Cell and Developmental Biology W93-70240  
199-40-22

**GENETICS**

Space Radiation W93-70228  
199-04-14  
Cell and Developmental Biology W93-70239  
199-40-21  
The Early Evolution of Life W93-70248  
199-52-32

**GEOCENTRIC COORDINATES**

GPS-Based DSN Calibration System W93-70530  
310-10-61

**GEOCHEMISTRY**

Automation and Robotics W93-70127  
586-02-00  
Planetary Materials: General Operations and Laboratory Facilities W93-70150  
152-30-40  
Planetary Instrument Definition and Development W93-70169  
157-03-50  
Impact Catastrophism on the Terrestrial Planets W93-70222  
196-88-01

**GEOCHRONOLOGY**

Planetology W93-70139  
151-01-70  
Planetary Materials: Geochronology W93-70146  
152-14-40  
Planetary Materials: Surface and Exposure Studies W93-70147  
152-17-40  
Impact Catastrophism on the Terrestrial Planets W93-70222  
196-88-01  
Paleoecological Studies of CH<sub>4</sub> Emissions W93-70360  
463-43-07  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico W93-70409  
465-43-03

**GEODESY**

U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy W93-70166  
155-20-02  
Relativity, Cosmology, and Gravitational Radiation W93-70185  
188-41-22  
Monitoring Global Sea Level with Altimeter Transponders W93-70328  
461-38-02  
Crustal Strain Modeling Using Finite Element Methods W93-70388  
465-12-03  
Dynamics of North American-Pacific Shear W93-70390  
465-13-02  
GPS Strain Monitoring in the New Madrid Seismic Zone W93-70391  
465-13-05  
Parkfield GPS Experiment W93-70393  
465-13-08  
Global Tectonic Motions W93-70394  
465-14-01  
Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints W93-70395  
465-14-07  
North American Fiducial Network W93-70397  
465-14-11  
Geopotential Temporal Variations W93-70400  
465-17-02  
Lateral Variations in Solid Tides W93-70401  
465-17-04  
Short-Period Tropospheric Noise in Continuous GPS Measurements W93-70402  
465-27-02  
Crustal Dynamics Data Information System (CDDIS) W93-70459  
579-32-06  
Geophysical Analysis and Modeling of LLR Data W93-70461  
579-36-09  
Rapid Earth Orientation Changes W93-70462  
579-36-10  
Core-Mantle Excitation W93-70463  
579-36-11

**GEODETIC ACCURACY**

Parkfield GPS Experiment W93-70393  
465-13-08  
GPS/VLBI Vertical Measurement W93-70396  
465-14-09

North American Fiducial Network W93-70397  
465-14-11  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula W93-70408  
465-42-06

**GEODETIC SATELLITES**

Large Scale Air-Sea Interactions W93-70433  
578-22-26  
Global Monthly Mean Ocean Variability W93-70435  
578-22-29  
Topography from SEASAT and GEOSAT Overland Altimetry W93-70469  
579-42-03

**GEODETIC SURVEYS**

Modeling of Convergent Plate Margin Deformation W93-70389  
465-12-06  
Dynamics of North American-Pacific Shear W93-70390  
465-13-02  
Parkfield GPS Experiment W93-70393  
465-13-08  
Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints W93-70395  
465-14-07  
GPS/VLBI Vertical Measurement W93-70396  
465-14-09  
North American Fiducial Network W93-70397  
465-14-11  
Upper Mantle Seismic P and S Wave Study W93-70399  
465-16-01  
Short-Period Tropospheric Noise in Continuous GPS Measurements W93-70402  
465-27-02  
Crustal Dynamics Data Information System (CDDIS) W93-70459  
579-32-06

**GEODYNAMICS**

Hydrologic Process Studies W93-70330  
461-50-00  
Crustal Strain Modeling Using Finite Element Methods W93-70388  
465-12-03  
Dynamics of North American-Pacific Shear W93-70390  
465-13-02  
Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment W93-70392  
465-13-06  
Global Tectonic Motions W93-70394  
465-14-01  
North American Fiducial Network W93-70397  
465-14-11  
Theory of Geodetic Transformations W93-70398  
465-15-06  
Geopotential Temporal Variations W93-70400  
465-17-02  
Lateral Variations in Solid Tides W93-70401  
465-17-04  
Goldstone DOSE Support W93-70403  
465-28-02  
Crustal Dynamics Data Information System (CDDIS) W93-70459  
579-32-06  
Earth Rotation and Mantle Structure W93-70460  
579-36-03  
Geophysical Analysis and Modeling of LLR Data W93-70461  
579-36-09  
Rapid Earth Orientation Changes W93-70462  
579-36-10

**GEOGRAPHIC INFORMATION SYSTEMS**

Navigation Ancillary Information Facility (NAIF) W93-70480  
656-61-05  
Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data W93-70493  
656-65-22  
ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems W93-70499  
665-35-00

**GEIDS**

Upper Mantle Seismic P and S Wave Study W93-70399  
465-16-01

**GEOLOGICAL FAULTS**

Dynamics of North American-Pacific Shear W93-70390  
465-13-02  
GPS Strain Monitoring in the New Madrid Seismic Zone W93-70391  
465-13-05  
Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment W93-70392  
465-13-06  
Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints W93-70395  
465-14-07

**GEOLOGICAL SURVEYS**

Thermal Infrared Science Support W93-70352  
462-75-74  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula W93-70408  
465-42-06

**GEOLOGY**

Science Sensing (Remote) W93-70111  
582-03-00  
Thermal Infrared Science Support W93-70352  
462-75-74  
Global Tectonic Motions W93-70394  
465-14-01  
Geological Interpretation of Magsat Anomaly Data W93-70405  
465-32-06  
ARISTOTELES GPS Receiver Development W93-70406  
465-35-05  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula W93-70408  
465-42-06  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico W93-70409  
465-43-03  
Remote Sensing of Active and Recently Active Volcanic Features W93-70411  
465-44-01  
Bibliography for Land Processes Publications W93-70473  
579-82-00  
Computer and Information Systems Support W93-70474  
579-82-90  
Windows on Global Change W93-70503  
665-82-03

**GEOMAGNETISM**

Modeling of the Main Magnetic Field W93-70457  
579-31-02  
Geomagnetic Modeling of Core Fluid Motions W93-70458  
579-31-07

**GEO MORPHOLOGY**

Validations of Passive Microwave Snow Water Equivalent Algorithm W93-70319  
461-13-00

**GEO PHYSICAL SATELLITES**

Polar Exchange at the Sea Surface: JPL Component W93-70282  
429-81-64  
Active/Passive Sea Ice Analysis W93-70437  
578-32-24

**GEO PHYSICS**

Science Sensing (Remote) W93-70111  
582-03-00  
Planetology W93-70139  
151-01-70  
Planetary Instrument Definition and Development W93-70169  
157-03-50  
Planetary Orbital/Flyby Laser Altimeter W93-70172  
157-03-80  
Automated Geophysical Processor Development for the Alaska SAR Facility W93-70273  
428-82-11  
Interannual Variability of Global Cycles W93-70276  
429-81-06  
Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions W93-70294  
432-48-00  
Process Studies: Radiation Dynamics and Hydrology, Radiation and Dynamic Processes W93-70308  
460-20-00  
Hydrologic Process Studies W93-70330  
461-50-00  
Microwave Process Studies of Sea Ice Properties W93-70333  
461-62-10  
Ice Sheet Geophysical Investigations Using Imaging Radar W93-70336  
461-66-18  
Radar Scattering Inversion: Forested Areas W93-70348  
462-62-04  
Thermal Infrared Science Support W93-70352  
462-75-74  
Theory of Geodetic Transformations W93-70398  
465-15-06  
Geopotential Temporal Variations W93-70400  
465-17-02  
Geological Interpretation of Magsat Anomaly Data W93-70405  
465-32-06  
ARISTOTELES GPS Receiver Development W93-70406  
465-35-05  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico W93-70409  
465-43-03  
Remote Sensing of Active and Recently Active Volcanic Features W93-70411  
465-44-01  
Measurement of Volcanic Gases W93-70414  
465-44-05  
Airborne Synthetic Aperture Radar (AIRSAR) Operations W93-70420  
465-68-01  
Active/Passive Sea Ice Analysis W93-70437  
578-32-24  
Sea Ice Motion in the Pacific Sector of the Arctic W93-70438  
578-35-01

- Problems in Interpreting Satellite Crustal Anomaly Field Data  
579-31-01 W93-70456
- Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458
- Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459
- Earth Rotation and Mantle Structure  
579-36-03 W93-70460
- Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461
- Rapid Earth Orientation Changes  
579-36-10 W93-70462
- Core-Mantle Excitation  
579-36-11 W93-70463
- Biogeochemistry and Geophysics Modeling and Data Analysis  
579-42-01 W93-70467
- Topography from SEASAT and GEOSAT Overland Altimetry  
579-42-03 W93-70469
- ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- GEOPOTENTIAL**  
Geopotential Temporal Variations  
465-17-02 W93-70400
- GEOSAT SATELLITES**  
Retracking of Topex Waveform Data  
461-34-01 W93-70326
- Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430
- Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431
- Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
- Topography from SEASAT and GEOSAT Overland Altimetry  
579-42-03 W93-70469
- GEOSYNCHRONOUS ORBITS**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064
- Information and Controls Research and Technology  
506-59-00 W93-70089
- Space Communications Research and Technology  
506-72-00 W93-70098
- GPS-Based DSN Calibration System  
310-10-61 W93-70530
- Optical Communications  
310-20-35 W93-70533
- GERMANIUM**  
Science Sensing (Remote)  
582-03-00 W93-70109
- Surface Systems  
583-02-00 W93-70117
- Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206
- Gamma-Ray Spectroscopy  
188-46-58 W93-70208
- Integral Mission Definition Study  
188-78-01 W93-70211
- GIOTTO MISSION**  
Magnetospheric Coupling  
432-36-00 W93-70293
- GLACIERS**  
Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336
- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- Evolution of Volcanic Terrains  
465-44-02 W93-70412
- Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416
- Earth Rotation and Mantle Structure  
579-36-03 W93-70460
- ASF SAR Interferometry  
665-35-01 W93-70500
- GLACIOLOGY**  
Geopotential Temporal Variations  
465-17-02 W93-70400
- GLASS**  
Glasses and Ceramics  
674-26-05 W93-70515
- Glasses and Ceramics  
674-26-08 W93-70516
- GLOBAL ATMOSPHERIC RESEARCH PROGRAM**  
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis  
578-10-00 W93-70421
- Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
578-40-00 W93-70441
- Rapid Earth Orientation Changes  
579-36-10 W93-70462
- GLOBAL POSITIONING SYSTEM**  
Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282
- Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328
- Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389
- Dynamics of North American-Pacific Shear  
465-13-02 W93-70390
- GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391
- Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
465-13-06 W93-70392
- Parkfield GPS Experiment  
465-13-08 W93-70393
- Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395
- GPS/VLBI Vertical Measurement  
465-14-09 W93-70396
- North American Fiducial Network  
465-14-11 W93-70397
- Short-Period Tropospheric Noise in Continuous GPS Measurements  
465-27-02 W93-70402
- ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406
- Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459
- Rapid Earth Orientation Changes  
579-36-10 W93-70462
- ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- GPS-Based DSN Calibration System  
310-10-61 W93-70530
- GOES SATELLITES**  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504
- GONDOLAS**  
Mars 94 Winds  
155-20-04 W93-70168
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375
- GOVERNMENT PROCUREMENT**  
Propulsion Research and Technology  
506-42-00 W93-70069
- GOVERNMENT/INDUSTRY RELATIONS**  
Advanced Turboprop Systems  
535-03-00 W93-70045
- Earth-To-Orbit Transportation  
584-03-00 W93-70119
- GOVERNMENTS**  
Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491
- GRANTS**  
Computational Aerosciences  
509-10-00 W93-70028
- Earth and Space Sciences  
509-20-00 W93-70033
- Graduate Fellowships  
578-97-16 W93-70447
- GRAPHIC ARTS**  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488
- Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490
- GRAPHS (CHARTS)**  
Graphical Methods for Science Visualization and Data Analysis  
656-65-05 W93-70489
- GRASSES**  
Soil Moisture from SAR  
462-62-05 W93-70349
- GRASSLANDS**  
Validations of Passive Microwave Snow Water Equivalent Algorithm  
461-13-00 W93-70319
- GRATINGS (SPECTRA)**  
Optical Technology for Space Astronomy  
188-41-23 W93-70186
- GRAVITATION**  
In-Space Experiments  
506-74-00 W93-70105
- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151
- Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399
- Biotechnology Research  
674-23-01 W93-70508
- Glasses and Ceramics  
674-26-08 W93-70516
- GRAVITATIONAL COLLAPSE**  
Center for Star Formation Studies  
399-20-01 W93-70260
- GRAVITATIONAL CONSTANT**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185
- GRAVITATIONAL EFFECTS**  
Automation and Robotics  
586-02-00 W93-70129
- Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185
- Cardiopulmonary Physiology  
199-14-12 W93-70233
- Structural Biosystems  
199-40-42 W93-70242
- Flight Research  
199-40-62 W93-70243
- Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461
- Electronic Materials  
674-21-08 W93-70506
- Combustion Science  
674-22-05 W93-70507
- Biotechnology Research  
674-23-01 W93-70508
- Biotechnology  
674-23-08 W93-70509
- Fluid Physics  
674-24-00 W93-70510
- Fluid Physics  
674-24-05 W93-70511
- Fluid Physics  
674-24-08 W93-70512
- Metals and Alloys  
674-25-08 W93-70514
- Glasses and Ceramics  
674-26-08 W93-70516
- Ground Experiment Operations  
674-28-08 W93-70519
- Consulting and Program Support  
674-29-08 W93-70520
- GRAVITATIONAL FIELDS**  
Mars 94 Gravity  
155-20-03 W93-70167
- Space Human Factors Behavior and Performance  
199-06-11 W93-70229
- Neuroscience (Biomedical)  
199-16-12 W93-70234
- Geopotential Temporal Variations  
465-17-02 W93-70400
- Earth Rotation and Mantle Structure  
579-36-03 W93-70460
- Neptune Data Analysis Program  
889-59-00 W93-70526
- GRAVITATIONAL PHYSIOLOGY**  
Longitudinal Studies (Medical Operations Longitudinal Studies)  
199-02-31 W93-70224
- General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232
- Neuroscience (Biomedical)  
199-16-12 W93-70234
- Cell and Development Biology  
199-40-21 W93-70239
- Cell and Developmental Biology  
199-40-22 W93-70240
- Integrative Biology  
199-40-32 W93-70241
- Structural Biosystems  
199-40-42 W93-70242
- Biotechnology Research  
674-23-01 W93-70508
- GRAVITATIONAL WAVES**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185
- Gravity Wave Mission Definition Study  
188-78-01 W93-70212
- GRAVITY WAVES**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185
- Gravity Wave Mission Definition Study  
188-78-01 W93-70212
- Thermosphere-Ionosphere-Mesosphere-Magnetospheric Interactions  
432-48-00 W93-70294
- Microwave Temperature Profiler  
464-14-20 W93-70374



## GREAT PLAINS CORRIDOR (NORTH AMERICA)

## GREAT PLAINS CORRIDOR (NORTH AMERICA)

Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions

461-13-01 W93-70321

Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions

579-42-02 W93-70468

## GREENHOUSE EFFECT

Science Sensing (Remote)

582-03-00 W93-70110

Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)

428-81-10 W93-70263

Laser Induced Fluorescence: A Technique for Remote  
Assessment of Photosynthetic Efficiency and Detection  
of Environmental Stress

462-31-63 W93-70339

Measurement of Volcanic Gases

465-44-05 W93-70414

Remote Sensing of Air-Sea Fluxes

578-12-19 W93-70426

Global Climate Modeling

578-41-01 W93-70442

Windows on Global Change

665-82-03 W93-70503

Neptune Data Analysis Program

889-59-00 W93-70526

## GREENLAND

Active/Passive Sea Ice Analysis

578-32-24 W93-70437

Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate

578-35-02 W93-70439

Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data

665-35-09 W93-70501

## GRID GENERATION (MATHEMATICS)

Earth and Space Sciences

509-20-00 W93-70035

## GROUND BASED CONTROL

Expert Systems for Automation of Operations

310-40-47 W93-70547

## GROUND OPERATIONAL SUPPORT SYSTEM

Materials and Structures Research and Technology

505-63-00 W93-70009

Controls, Guidance, and Human Factors Research and  
Technology

505-64-00 W93-70010

Earth-to-Orbit Transportation

584-03-00 W93-70118

Automation and Robotics

586-02-00 W93-70127

Automation and Robotics

586-02-00 W93-70133

Ground Experiment Operations

674-28-08 W93-70519

## GROUND STATIONS

Ground-Based Support of Solar Physics

170-38-52 W93-70179

Hydrologic Process Studies

461-50-00 W93-70330

Advanced Search and Rescue Techniques

669-30-10 W93-70504

## GROUND SUPPORT EQUIPMENT

High Energy Astrophysics International Programs

440-62-59 W93-70299

AVIRIS Operations

463-75-63 W93-70364

## GROUND SUPPORT SYSTEMS

Stratospheric Observatory for Infrared Astronomy

(SOFIA)

188-78-60 W93-70216

## GROUND TESTS

Flight Systems Research and Technology

505-68-00 W93-70013

Fly-By-Light/Power-By-Wire Technology

538-01-00 W93-70059

Fly-By-Light/Power-By-Wire

538-01-00 W93-70060

Systems Analysis

506-49-00 W93-70085

In-Space Technology Experiments

506-74-00 W93-70106

Space Transportation

584-04-00 W93-70122

Earth-Orbiting Platforms

585-03-00 W93-70124

Earth-Orbiting Platforms

585-03-00 W93-70125

Earth-Orbiting Platforms

585-03-00 W93-70126

Airborne Synthetic Aperture Radar (AIRSAR)

Operations

462-75-62 W93-70351

Airborne Synthetic Aperture Radar (AIRSAR)

Operations

465-68-01 W93-70420

Satellite Data Sets and Algorithm Testing

579-42-11 W93-70470

## GROUND TRACKS

Monitoring Global Sea Level with Altimeter

Transponders

461-38-02 W93-70328

## GROUND TRUTH

Desert Mesoscale/PBL

461-13-02 W93-70322

Satellite Radar for Forest Structure

462-41-61 W93-70343

ERS-1 Studies of Forest Ecosystems

579-41-08 W93-70466

Satellite Data Sets and Algorithm Testing

579-42-11 W93-70470

Geographical Information System for Fusion and

Analysis of High-Resolution Remote Sensing and Ground

Truth Data

656-65-22 W93-70493

## GROUND WATER

Global Hydrologic Cycle

429-81-16 W93-70278

Topography from SEASAT and GEOSAT Overland

Altimetry

579-42-03 W93-70469

## GROUND WIND

Scatterometer Research

461-31-09 W93-70323

Large Scale Air-Sea Interactions

578-22-26 W93-70433

Global Monthly Mean Ocean Variability

578-22-29 W93-70435

ERS-1 SAR Investigation of Ice Kinematics and Surface

Wind Fields in the Weddell Sea

665-35-10 W93-70502

## GROUP DYNAMICS

Behavior, Performance and Human Factors

199-06-12 W93-70231

## GULF OF CALIFORNIA (MEXICO)

Application of Remote Sensing Imagery to Neotectonic

Problems in the Baja California Peninsula

465-42-06 W93-70408

## GULF STREAM

Scatterometer Research

461-31-09 W93-70323

## H

## HABITABILITY

Remote Sensing of Active and Recently Active Volcanic

Features

465-44-01 W93-70411

## HABITATS

In-Space Experiments

506-74-00 W93-70102

Environmental Health

199-04-11 W93-70227

## HALF LIFE

Planetary Materials: Geochronology

152-14-40 W93-70146

## HALLEY'S COMET

Magnetospheric Coupling

432-36-00 W93-70293

## HALOPHILES

The Early Evolution of Life

199-52-32 W93-70248

## HANDBOOKS

Propulsion Research and Technology

506-42-00 W93-70069

## HARDWARE

Flight Research

199-40-72 W93-70244

Proposal for a High-Energy Imaging Device (HEIDI) on

a Balloon

879-11-48 W93-70523

Communications and Telemetry

310-20-37 W93-70535

## HARRIER AIRCRAFT

High-Performance Flight Research

533-02-00 W93-70041

## HAZARDS

Global Assessment of Active Volcanism

428-81-96 W93-70270

## HAZE

Planetary Clouds Particulates and Ices

154-30-80 W93-70155

## HEALTH

Clinical Medicine Technology Watch

199-02-31 W93-70223

Space Radiation Effects and Protection (Environmental

Health)

199-04-00 W93-70225

Radiation Health

199-04-11 W93-70226

Environmental Health

199-04-11 W93-70227

General Biomedical: Center and Headquarters Support

199-08-11 W93-70232

Neuroscience (Biomedical)

199-16-12 W93-70234

Regulatory Physiology (Biomedical)

199-18-12 W93-70235

## HEAO 2

High Energy Astrophysics: Data Analysis, Interpretation

and Theoretical Studies

188-46-01 W93-70205

## HEART FUNCTION

Cardiopulmonary Physiology

199-14-12 W93-70233

## HEAT BALANCE

Modeling and Multispectral Satellite Data Analysis for

Land Surface Study with Special Emphasis on Hot Arid

and Semi-Arid Regions

461-13-01 W93-70321

Modeling and Multispectral Satellite Data Analysis for

Land Surface Study with Special Emphasis on Hot Arid

and Semi-Arid Regions

579-42-02 W93-70468

## HEAT FLUX

Biosphere Atmospheric Interactions

429-81-26 W93-70279

Polar Exchange at the Sea Surface: JPL Component

429-81-64 W93-70282

Convective Transport in the Solar Nebula

452-22-91 W93-70303

IR Remote Sensing of SST

460-21-28 W93-70310

Remote Sensing of Air-Sea Fluxes

578-12-19 W93-70426

Active/Passive Sea Ice Analysis

578-32-24 W93-70437

Subgrid Variation of Surface Parameters

578-42-15 W93-70444

Soil/Canopy Moisture and Temperature Profiles Using

Remote Sensing and Modeling

579-42-13 W93-70471

## HEAT PIPES

Space Energy Conversion Research and Technology

506-41-00 W93-70066

In-Space Experiments

506-74-00 W93-70105

## HEAT PUMPS

Space Energy Conversion Research and Technology

506-41-00 W93-70066

## HEAT RADIATORS

Earth-Orbiting Platforms

585-03-00 W93-70124

## HEAT RESISTANT ALLOYS

Enabling Propulsion Materials

537-04-00 W93-70058

## HEAT SHIELDING

Solar Probe ATD

433-06-00 W93-70296

## HEAT SINKS

Meteorological Parameters Extraction

578-12-20 W93-70427

## HEAT SOURCES

Global Assessment of Active Volcanism

428-81-94 W93-70269

## HEAT STORAGE

Materials and Structures Research and Technology

506-43-00 W93-70073

Space Flight Research and Technology

506-48-00 W93-70078

Space Flight Research and Technology

506-48-00 W93-70080

Earth-Orbiting Platforms

585-03-00 W93-70124

## HEAT TRANSFER

Earth-Orbiting Platforms

585-03-00 W93-70124

Energetics of Interstellar Clouds

399-20-00 W93-70257

Role of Air-Sea Exchanges and Ocean Circulation

(Computing)

## HUMAN PERFORMANCE

Space Energy Conversion Research and Technology	
506-41-00	W93-70067
Materials and Structures Research and Technology	
506-43-00	W93-70076
Space Transportation	
584-04-00	W93-70123
<b>HIGH RESOLUTION</b>	
Science Sensing (Remote)	
582-03-00	W93-70111
Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)	
157-03-90	W93-70173
Cosmic and Heliospheric Physics	
170-10-10	W93-70177
Deep Optical/UV Imaging of Quasars Below the Lyman Limit	
188-41-21	W93-70183
Optical/UV Laboratory Astrophysics	
188-41-57	W93-70191
Laboratory Astrophysics	
188-44-57	W93-70203
Gamma-Ray Spectroscopy	
188-46-58	W93-70208
High Throughput X-Ray Spectroscopy	
188-46-59	W93-70210
Integral Mission Definition Study	
188-78-01	W93-70211
Ground-Based Infrared Astronomy	
196-41-50	W93-70218
Advanced Infrared Astronomy	
196-41-54	W93-70220
Automated Geophysical Processor Development for the Alaska SAR Facility	
428-82-11	W93-70273
Global Assessment of Active Volcanism	
429-81-94	W93-70285
Foreign Visitor Support	
429-97-04	W93-70290
Ice Sheet Geophysical Investigations Using Imaging Radar	
461-66-18	W93-70336
Airborne Interferometric Topography	
462-74-01	W93-70350
Far Infrared Balloon Radiometer for OH	
464-12-15	W93-70370
Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere	
464-23-00	W93-70380
Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements	
464-23-08	W93-70381
Short-Period Tropospheric Noise in Continuous GPS Measurements	
465-27-02	W93-70402
Airborne Interferometric Topography	
465-67-04	W93-70419
Meteorological Parameters Extraction	
578-12-20	W93-70427
Atmospheric Parameter Mapping	
578-12-21	W93-70428
Outgoing Spectral Radiance: A Climate Diagnostic	
578-12-59	W93-70429
Sea Ice Motion in the Pacific Sector of the Arctic	
578-35-01	W93-70438
Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions	
579-43-00	W93-70472
<b>HIGH SPEED</b>	
Advanced Rotorcraft Technology	
532-06-00	W93-70040
High-Performance Flight Research	
533-02-00	W93-70043
Atmospheric Effects	
537-01-00	W93-70049
Community Noise and Sonic Boom	
537-03-00	W93-70057
Materials and Structures Research and Technology	
506-43-00	W93-70077
DSN Data Processing and Productivity	
310-40-73	W93-70551
<b>HIGH TEMPERATURE</b>	
Materials and Structures Research and Technology	
505-63-00	W93-70007
Hypersonic Research and Technology	
505-70-00	W93-70022
Enabling Propulsion Materials	
537-04-00	W93-70058
Aerothermodynamics Research and Technology	
506-40-00	W93-70063
Space Energy Conversion Research and Technology	
506-41-00	W93-70067
Materials and Structures Research and Technology	
506-43-00	W93-70074
<b>HIGH TEMPERATURE ENVIRONMENTS</b>	
Materials and Structures Research and Technology	
505-63-00	W93-70000

Advanced Programs Theoretical Biology	W93-70252
199-55-19	
<b>HIGH TEMPERATURE SUPERCONDUCTORS</b>	
Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers	
157-05-50	W93-70175
Radio Systems Development	
310-20-66	W93-70540
<b>HIGH THRUST</b>	
Propulsion Research and Technology	
506-42-00	W93-70068
<b>HIGHLANDS</b>	
Early Mars Impact Basins, Crustal Dichotomy, Volcanic Resurfacing	
151-02-00	W93-70140
<b>HIGHLY MANEUVERABLE AIRCRAFT</b>	
High Performance Flight Research	
533-02-00	W93-70042
<b>HIMALAYAS</b>	
Topography from SEASAT and GEOSAT Overland Altimetry	
579-42-03	W93-70469
<b>HIPPARCOS SATELLITE</b>	
HIPPARCOS VLBI	
399-18-00	W93-70256
<b>HOLOGRAPHY</b>	
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis	
656-65-25	W93-70495
<b>HOMEOSTASIS</b>	
Integrative Biology	
199-40-32	W93-70241
<b>HUBBLE SPACE TELESCOPE</b>	
Observatory Systems	
582-04-00	W93-70115
Earth-Orbiting Platforms	
585-03-00	W93-70126
Automation and Robotics	
586-02-00	W93-70127
UV Astronomy and Data Systems	
188-41-51	W93-70189
Optical/UV Laboratory Astrophysics	
188-41-57	W93-70191
Two-Phase Nebulae	
452-22-93	W93-70304
<b>HUMAN BEHAVIOR</b>	
Behavior and Performance Research	
199-06-11	W93-70230
<b>HUMAN BEINGS</b>	
Cardiopulmonary Physiology	
199-14-12	W93-70233
<b>HUMAN FACTORS ENGINEERING</b>	
Controls, Guidance, and Human Factors Research and Technology	
505-64-00	W93-70010
Controls, Guidance and Human Factors Research and Technology	
505-64-00	W93-70011
Controls, Guidance and Human Factors Research and Technology	
505-64-00	W93-70012
Information and Controls Research and Technology	
506-59-00	W93-70088
Human Support Research and Technology	
506-71-00	W93-70094
Space Human Factors Behavior and Performance	
199-06-11	W93-70229
Behavior, Performance and Human Factors	
199-06-12	W93-70231
Planning and Scheduling Systems Technology	
310-20-36	W93-70534
Human-to-Machine Interface Technology	
310-40-37	W93-70545
<b>HUMAN PERFORMANCE</b>	
Controls, Guidance, and Human Factors Research and Technology	
505-64-00	W93-70010
Controls, Guidance and Human Factors Research and Technology	
505-64-00	W93-70011
Information and Controls Research and Technology	
506-59-00	W93-70092
Human Support Research and Technology	
506-71-00	W93-70094
Automation and Robotics	
586-02-00	W93-70130
Space Human Factors Behavior and Performance	
199-06-11	W93-70229
Behavior and Performance Research	
199-06-11	W93-70230
Behavior, Performance and Human Factors	
199-06-12	W93-70231
Expert Systems for Automation of Operations	
310-40-47	W93-70547

## HUMIDITY

## HUMIDITY

- Micro Weather Stations for Mars  
157-04-80 W93-70174
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426
- Meteorological Parameters Extraction  
578-12-20 W93-70427

## HYBRID PROPULSION

- Earth-to-Orbit Transportation  
584-03-00 W93-70121

## HYBRID ROCKET ENGINES

- Earth-To-Orbit Transportation  
584-03-00 W93-70119

## HYDRATION

- A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143

## HYDROCARBONS

- Laboratory Astrophysics  
188-44-57 W93-70201
- Properties of Interstellar PAH's  
188-44-57 W93-70202
- The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons  
399-50-00 W93-70261
- Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386

## HYDROCHLORIC ACID

- Global Assessment of Active Volcanism  
428-81-96 W93-70270

## HYDROCLIMATOLOGY

- Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423
- Subgrid Variation of Surface Parameters  
578-42-15 W93-70444
- Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445

## HYDRODYNAMICS

- Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199
- Convective Transport in the Solar Nebula  
452-22-91 W93-70303

## HYDROGEN

- Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245

## HYDROGEN EMBRITTLEMENT

- Materials and Structures Research and Technology  
506-43-00 W93-70076

## HYDROGEN MASERS

- In-Space Technology Experiments  
506-74-00 W93-70106

## HYDROGEN OXYGEN ENGINES

- Earth-to-Orbit Transportation  
584-03-00 W93-70118
- Earth-to-Orbit Transportation  
584-03-00 W93-70121
- Space Transportation  
584-04-00 W93-70122

## HYDROGEN PEROXIDE

- Ground-Based Infrared Astronomy  
196-41-50 W93-70218

## HYDROGEN SULFIDE

- Measurement of Volcanic Gases  
465-44-05 W93-70414

## HYDROLOGICAL CYCLE

- Global Hydrologic Cycle  
428-81-16 W93-70264
- Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267
- Interannual Variability of Global Cycles  
429-81-06 W93-70276
- Role of Air-Sea Exchanges and Ocean Circulation  
(Science)  
429-81-10 W93-70277
- Global Hydrologic Cycle  
429-81-16 W93-70278
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- Project to Interface Modeling  
429-81-72 W93-70283
- Hydrologic Processes, Field Study  
461-10-00 W93-70318
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot And  
and Semi-And Regions  
461-13-01 W93-70321
- Airborne ESTAR  
461-38-01 W93-70327
- Hydrologic Process Studies  
461-50-00 W93-70330
- GEWEX Program Support  
461-50-03 W93-70331

- Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338
- Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345
- Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363
- Climate Stability: The Role of the Hydrological Cycle  
and the Thermohaline Circulation  
578-31-14 W93-70436
- Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445
- Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451

## HYDROLOGY

- Process Studies: Radiation Dynamics and Hydrology,  
Radiation and Dynamic Processes  
460-20-00 W93-70308
- Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320
- Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336
- Land Surface Climatology: HAPEX  
462-32-00 W93-70340
- Global Climate Modeling  
578-41-01 W93-70442
- Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445
- ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499

## HYDROLOGY MODELS

- Forest/Climate Interactions  
462-21-00 W93-70337
- Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423
- Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445
- A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496

## HYDROSTATICS

- Glasses and Ceramics  
674-26-08 W93-70516

## HYDROXYL RADICALS

- Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370
- Quantitative Infrared Spectroscopy  
of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

## HYPERSONIC AIRCRAFT

- Aerodynamics Research and Technology  
505-59-00 W93-70002

## HYPERSONIC BOUNDARY LAYER

- Aerodynamics Research and Technology  
505-59-00 W93-70003

## HYPERSONIC FLIGHT

- Hyperperson Research and Technology  
505-70-00 W93-70020
- Hyperperson Training and Research  
505-70-00 W93-70021
- Hyperperson Research and Technology  
505-70-00 W93-70022
- Aerothermodynamics Research and Technology  
506-40-00 W93-70062

## HYPERSONIC FLOW

- Hyperperson Training and Research  
505-70-00 W93-70021
- Hyperperson Research and Technology  
505-70-00 W93-70022
- Aerothermodynamics Research and Technology  
506-40-00 W93-70062
- Hyperperson Research and Technology  
506-73-00 W93-70100

## HYPERSONIC SPEED

- Hyperperson Training and Research  
505-70-00 W93-70021
- Hyperperson Research and Technology  
505-70-00 W93-70022

## HYPERSONIC VEHICLES

- Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70012
- Systems Analysis  
505-69-00 W93-70016
- Hyperperson Research and Technology  
505-70-00 W93-70020
- Hyperperson Research and Technology  
505-70-00 W93-70022

- Hyperperson Research and Technology  
505-70-00 W93-70023
- Hyperperson Research and Technology  
506-73-00 W93-70100
- Hyperperson Research and Technology  
506-73-00 W93-70101

## HYPERSONIC WIND TUNNELS

- Aerothermodynamics Research and Technology  
506-40-00 W93-70062

## HYPERSONICS

- Systems Analysis  
505-69-00 W93-70016
- Hyperperson Training and Research  
505-70-00 W93-70021
- Hyperperson Research and Technology  
505-70-00 W93-70022
- Hyperperson Research and Technology  
505-70-00 W93-70023
- Aerothermodynamics Research and Technology  
506-40-00 W93-70063
- Hyperperson Research and Technology  
506-73-00 W93-70100
- Hyperperson Research and Technology  
506-73-00 W93-70101

## HYPERVELOCITY IMPACT

- Materials and Structures Research and Technology  
506-43-00 W93-70077

## HYPOKINESIA

- Cell and Development Biology  
199-40-21 W93-70239

## ICE

- Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145
- Laboratory Astrophysics  
188-44-57 W93-70203
- The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons  
399-50-00 W93-70261
- Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306
- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate  
578-35-02 W93-70439
- ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502

## ICE CLOUDS

- Planetary Clouds Particulates and Ices  
154-30-80 W93-70155
- Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373
- Microwave Temperature Profiler  
464-14-20 W93-70374
- Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450

## ICE FORMATION

- Flight Systems Research and Technology  
505-68-00 W93-70014
- Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

## ICE PREVENTION

- Flight Systems Research and Technology  
505-68-00 W93-70014

## ICE REPORTING

- Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336
- Active/Passive Sea Ice Analysis  
578-32-24 W93-70437
- Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

## ICELAND

- Global Assessment of Active Volcanism  
429-81-95 W93-70286

## IDENTIFYING

- Planetary Hardcopy Preservation Task  
656-61-20 W93-70486

## IMAGE ANALYSIS

- Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336

- ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408
- Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420
- Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439
- LTP Computer Support  
579-41-04 W93-70465
- ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466
- Neptune Data Analysis  
889-59-00 W93-70524
- Neptune Data Analysis  
889-59-00 W93-70525
- IMAGE PROCESSING**
- Information and Controls Research and Technology  
506-59-00 W93-70088
- Information and Controls Research and Technology  
506-59-00 W93-70090
- Planetology  
151-01-70 W93-70139
- Mars 94 Winds  
155-20-04 W93-70168
- UV Astronomy and Data Systems  
188-41-51 W93-70189
- Musculoskeletal  
199-26-14 W93-70238
- Automated Geophysical Processor Development for the Alaska SAR Facility  
428-82-11 W93-70273
- Evolution of Volcanic Terrains  
465-44-02 W93-70412
- Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418
- Atmospheric Parameter Mapping  
578-12-21 W93-70428
- LTP Visualization  
578-97-53 W93-70449
- Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464
- LTP Computer Support  
579-41-04 W93-70465
- Computer and Information Systems Support  
579-82-90 W93-70474
- Planetary Hardcopy Preservation Task  
656-61-20 W93-70486
- Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490
- Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
656-65-22 W93-70493
- A Spatial Analysis and Modeling System for Environmental Management  
656-65-26 W93-70496
- Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498
- Windows on Global Change  
665-82-03 W93-70503
- IMAGERY**
- Imaging Studies of Comets  
196-41-52 W93-70219
- Heterogeneous Scene Models  
462-61-03 W93-70347
- Airborne Synthetic Aperture Radar (AIRSAR) Operations  
462-75-62 W93-70351
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408
- Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- IMAGING RADAR**
- Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320
- Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336
- IMAGING SPECTROMETERS**
- In-Space Technology Experiments  
506-74-00 W93-70107
- Space Data Systems  
586-03-00 W93-70136
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface  
428-81-80 W93-70268
- Global Assessment of Active Volcanism  
428-81-96 W93-70270
- Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274
- Global Assessment of Active Volcanism  
429-81-94 W93-70285
- Global Assessment of Active Volcanism  
429-81-96 W93-70287
- Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- AVIRIS Operations  
463-75-63 W93-70364
- AVIRIS Operations  
465-65-01 W93-70417
- IMAGING TECHNIQUES**
- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151
- U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166
- Imaging Spectropolarimeter  
157-03-70 W93-70170
- Astrometric Imaging Telescope  
157-03-70 W93-70171
- Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers  
157-05-50 W93-70175
- Deep Optical/UV Imaging of Quasars Below the Lyman Limit  
188-41-21 W93-70183
- Development of UV Photon Counting Geometrically Stable Array Detector - Multi-Anode Microchannel Array (MAMA)  
188-41-24 W93-70187
- UV Astronomy and Data Systems  
188-41-51 W93-70189
- Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206
- Gamma Ray Astronomy  
188-46-57 W93-70207
- Gamma-Ray Spectroscopy  
188-46-58 W93-70208
- Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217
- Imaging Studies of Comets  
196-41-52 W93-70219
- Musculoskeletal  
199-26-14 W93-70238
- Global Assessment of Active Volcanism  
429-81-94 W93-70285
- Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320
- Planetary Hardcopy Preservation Task  
656-61-20 W93-70486
- Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488
- Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490
- Proposal for a High-Energy Imaging Device (HEIDI) on a Balloon  
879-11-48 W93-70523
- Neptune Data Analysis Program  
889-59-00 W93-70526
- IMMUNE SYSTEMS**
- Regulatory Physiology (Biomedical)  
199-18-12 W93-70235
- IMP**
- Cosmic and Heliospheric Physics  
170-10-10 W93-70176
- IMPACT DAMAGE**
- Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- INDIAN OCEAN**
- Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430
- INDUSTRIES**
- Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491
- INFORMATION DISSEMINATION**
- Propulsion Research and Technology  
506-42-00 W93-70069
- Planetary Materials: Collection, Preservation and Distribution  
152-20-40 W93-70149
- Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459
- Neptune Data Analysis Program  
889-59-00 W93-70526
- INFORMATION FLOW**
- Construction of an Advanced Software Tool for Planetary Atmospheric Modeling  
656-65-24 W93-70494
- DSN Data Processing and Productivity  
310-40-73 W93-70551
- INFORMATION MANAGEMENT**
- Information and Controls Research and Technology  
506-59-00 W93-70092
- DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases  
656-65-21 W93-70492
- INFORMATION RETRIEVAL**
- Oceanic Remote Sensing Library  
461-66-16 W93-70335
- INFORMATION SYSTEMS**
- Systems Analysis  
506-49-00 W93-70085
- Information and Controls Research and Technology  
506-59-00 W93-70088
- Information and Controls Research and Technology  
506-59-00 W93-70089
- Information and Controls Research and Technology  
506-59-00 W93-70090
- Information and Controls Research and Technology  
506-59-00 W93-70091
- Information and Controls Research and Technology  
506-59-00 W93-70092
- Astrotech 21  
188-78-44 W93-70215
- NASA/IPAC Extragalactic Database  
399-20-00 W93-70259
- EOS IDS, EOSDIS Money  
426-81-36 W93-70266
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Thermal Infrared Science Support  
462-75-74 W93-70352
- Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409
- Radar-Altimeter Ice Data System  
578-97-20 W93-70448
- Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459
- Computer and Information Systems Support  
579-82-90 W93-70474
- Information Systems Newsletter  
656-50-65 W93-70477
- Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491
- DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases  
656-65-21 W93-70492
- Human-to-Machine Interface Technology  
310-40-37 W93-70545
- DSN Data Processing and Productivity  
310-40-73 W93-70551
- INFORMATION TRANSFER**
- Astrotech 21  
188-78-44 W93-70215
- INFRARED ABSORPTION**
- Laser Diode Sensor  
464-11-07 W93-70366
- Airborne IR Spectrometry  
464-12-00 W93-70367
- IR Solar Absorption Spectra  
464-12-05 W93-70368
- INFRARED ASTRONOMY**
- Observatory Systems  
582-04-00 W93-70115
- Research Computing Facility and Cataloging for Infrared  
188-44-01 W93-70192
- Infrared/Radio Research  
188-44-21 W93-70193
- IR Astronomy ATD/Cryo Optical Testing and Science Support Activities  
188-78-44 W93-70214
- Stratospheric Observatory for Infrared Astronomy (SOFIA)  
188-78-60 W93-70216
- Ground-Based Infrared Astronomy  
196-41-50 W93-70218
- Advanced Infrared Astronomy  
196-41-54 W93-70220
- Two-Phase Nebulae  
452-22-93 W93-70304
- INFRARED ASTRONOMY SATELLITE**
- Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar  
188-44-24 W93-70197

Energetics of Interstellar Clouds  
 399-20-00 W93-70257  
 IPAC Astrophysics Data System (ADS) Support  
 399-20-00 W93-70258  
 Infrared Studies of Planetary Debris Around Young Main  
 Sequence Stars  
 452-11-93 W93-70301  
**INFRARED DETECTORS**  
 Information and Controls Research and Technology  
 506-59-00 W93-70090  
 In-Space Technology Experiments  
 506-74-00 W93-70107  
 Science Sensing (Remote)  
 582-03-00 W93-70109  
 Observatory Systems  
 582-04-00 W93-70114  
 Imaging Spectropolarimeter  
 157-03-70 W93-70170  
 Planetary Instrument Development Program/Planetary  
 Astronomy High Temperature Superconductor  
 Bolometers  
 157-05-50 W93-70175  
 IR Remote Sensing of SST  
 460-21-28 W93-70310  
 Thermal Infrared Science Support  
 462-75-74 W93-70352  
**INFRARED IMAGERY**  
 Space Data Systems  
 586-03-00 W93-70136  
 Development of 1036 GHz Receiver for Astronomy and  
 Near IR Imaging at Palomar  
 188-44-24 W93-70197  
 Remote Sensing of Active and Recently Active Volcanic  
 Features  
 465-44-01 W93-70411  
**INFRARED INSTRUMENTS**  
 Infrared and Radio Astrophysics Technical  
 Development: Ground-Based Astronomical Instrument  
 188-44-23 W93-70195  
 Global Assessment of Active Volcanism  
 428-81-96 W93-70270  
 Studies of Volcanic SO<sub>2</sub>  
 428-81-99 W93-70271  
 Global Assessment of Active Volcanism  
 429-81-96 W93-70287  
 Studies of Volcanic SO<sub>2</sub>, Theory  
 429-81-99 W93-70289  
 Experimental Cloud Analysis Techniques  
 578-12-01 W93-70424  
 Meteorological Parameters Extraction  
 578-12-20 W93-70427  
 Atmospheric Parameter Mapping  
 578-12-21 W93-70428  
 Outgoing Spectral Radiance: A Climate Diagnostic  
 578-12-59 W93-70429  
**INFRARED INTERFEROMETERS**  
 Spectral and Physical Properties of Planetary  
 Atmospheric Constituents  
 154-50-80 W93-70156  
 Global Tectonic Motions  
 465-14-01 W93-70394  
 Outgoing Spectral Radiance: A Climate Diagnostic  
 578-12-59 W93-70429  
 Neptune Data Analysis  
 889-59-00 W93-70524  
**INFRARED LASERS**  
 Laser Laboratory Spectroscopy  
 464-23-09 W93-70382  
 Advanced Magnetometer  
 465-31-01 W93-70404  
**INFRARED RADAR**  
 CO<sub>2</sub> Lidar Backscatter Experiment  
 460-21-00 W93-70309  
 Lidar Target Calibration Facility  
 460-22-52 W93-70312  
 Atmospheric Backscatter Experiment  
 460-22-53 W93-70313  
**INFRARED RADIATION**  
 Space Flight Research and Technology  
 506-48-00 W93-70080  
 Information and Controls Research and Technology  
 506-59-00 W93-70090  
 Science Sensing (Remote)  
 582-03-00 W93-70109  
 Science Sensing (Remote)  
 582-03-00 W93-70112  
 Dynamics of Planetary Atmospheres  
 154-20-80 W93-70153  
 Mars 3-D Global Circulation Model  
 154-95-80 W93-70161  
 Research Computing Facility and Cataloging for  
 Infrared  
 188-44-01 W93-70192  
 Infrared and Radio Astrophysics Technical  
 Development: Ground-Based Astronomical Instrument  
 188-44-23 W93-70195

Infrared, Submillimeter, and Radio Astronomy  
 188-44-23 W93-70196  
 Theoretical Studies of Galaxies, the Interstellar Medium,  
 Molecular Clouds, Star Formation  
 188-44-53 W93-70199  
 Theory and Modeling: Infrared, Submillimeter, and  
 Radio  
 188-44-53 W93-70200  
 Ground-Based Infrared Astronomy  
 196-41-50 W93-70218  
 NASA/IPAC Extragalactic Database  
 399-20-00 W93-70259  
 Global Assessment of Active Volcanism  
 429-81-94 W93-70285  
 The Development of a Mid-Infrared Spectrometer for  
 the Infrared Telescope in Space  
 440-63-44 W93-70300  
 Infrared Studies of Planetary Debris Around Young Main  
 Sequence Stars  
 452-11-93 W93-70301  
 IR Remote Sensing of SST  
 460-21-28 W93-70310  
 Variations of Soil Moisture and Other Surface  
 Parameters During HAPEX-Sahel Experiment  
 462-32-03 W93-70341  
 Thermal Infrared Science Support  
 462-75-74 W93-70352  
 Remote Sensing of Active and Recently Active Volcanic  
 Features  
 465-44-01 W93-70411  
 Meteorological Parameters Extraction  
 578-12-20 W93-70427  
 Studies of Sea Surface Temperature and Topography  
 578-22-25 W93-70432  
 Neptune Data Analysis Program  
 889-59-00 W93-70526  
**INFRARED RADIOMETERS**  
 Remote Measurement of the Gain of Satellite  
 Radiometers: The NASA Aircraft Satellite Instrument  
 Calibration (NASIC) Project  
 428-82-18 W93-70274  
 Wind Measurement Assessment  
 460-28-41 W93-70314  
 Far Infrared Balloon Radiometer for OH  
 464-12-15 W93-70370  
**INFRARED SCANNERS**  
 Variations of Soil Moisture and Other Surface  
 Parameters During HAPEX-Sahel Experiment  
 462-32-03 W93-70341  
 Thermal Infrared Science Support  
 462-75-74 W93-70352  
 Evolution of Volcanic Terrains  
 465-44-02 W93-70412  
**INFRARED SIGNATURES**  
 Infrared Studies of Planetary Debris Around Young Main  
 Sequence Stars  
 452-11-93 W93-70301  
**INFRARED SPECTRA**  
 In-Space Technology Experiments  
 506-74-00 W93-70107  
 Laboratory Astrophysics  
 188-44-57 W93-70201  
 Laboratory Astrophysics  
 188-44-57 W93-70203  
 Ground-Based Infrared Astronomy  
 196-41-50 W93-70218  
 Advanced Infrared Astronomy  
 196-41-54 W93-70220  
 The Nature of Interstellar Dust, Ices and Polycyclic  
 Aromatic Hydrocarbons  
 399-50-00 W93-70261  
 Airborne Doppler Lidar  
 460-21-52 W93-70311  
 Quantitative Infrared Spectroscopy of Minor  
 Constituents of the Earth's Stratosphere  
 464-23-00 W93-70380  
 Infrared Laboratory Spectroscopy in Support of  
 Stratospheric Measurements  
 464-23-08 W93-70381  
 Laser Laboratory Spectroscopy  
 464-23-09 W93-70382  
 Multispectral Analysis of the Stratigraphic/Structural  
 Record, Southwest Mexico  
 465-43-03 W93-70409  
**INFRARED SPECTROMETERS**  
 Space Data Systems  
 586-03-00 W93-70136  
 Spectral and Physical Properties of Planetary  
 Atmospheric Constituents  
 154-50-80 W93-70156  
 Imaging Spectropolarimeter  
 157-03-70 W93-70170  
 Planetary Instrument Development Program/Planetary  
 Astronomy High Temperature Superconductor  
 Bolometers  
 157-05-50 W93-70175

Development of 1036 GHz Receiver for Astronomy and  
 Near IR Imaging at Palomar  
 188-44-24 W93-70197  
 Global Assessment of Active Volcanism  
 429-81-94 W93-70285  
 AVIRIS Operations  
 463-75-63 W93-70364  
 Global Tectonic Motions  
 465-14-01 W93-70394  
 Remote Sensing of Active and Recently Active Volcanic  
 Features  
 465-44-01 W93-70411  
 AVIRIS Operations  
 465-65-01 W93-70417  
 Outgoing Spectral Radiance: A Climate Diagnostic  
 578-12-59 W93-70429  
 Neptune Data Analysis  
 889-59-00 W93-70524  
**INFRARED SPECTROSCOPY**  
 Airborne IR Spectrometry  
 464-12-00 W93-70367  
 Chemical Kinetics of the Stratosphere  
 464-21-02 W93-70376  
 Kinetics of Tropospheric and Stratospheric Reactions  
 464-21-06 W93-70378  
 Quantitative Infrared Spectroscopy of Minor  
 Constituents of the Earth's Stratosphere  
 464-23-00 W93-70380  
 Infrared Laboratory Spectroscopy in Support of  
 Stratospheric Measurements  
 464-23-08 W93-70381  
 Laser Laboratory Spectroscopy  
 464-23-09 W93-70382  
 Kinetic Studies of Tropospheric Free Radicals  
 464-53-01 W93-70386  
 Neptune Data Analysis  
 889-59-00 W93-70524  
**INFRARED STARS**  
 Infrared Studies of Planetary Debris Around Young Main  
 Sequence Stars  
 452-11-93 W93-70301  
**INFRARED TELESCOPES**  
 Mars Atmosphere Dust Opacity  
 155-04-00 W93-70163  
 Infrared/Radio Research  
 188-44-21 W93-70193  
 IR Astronomy ATD/Cryo Optical Testing and Science  
 Support Activities  
 188-78-44 W93-70214  
 Volatiles in the Solar System  
 196-41-67 W93-70221  
 The Development of a Mid-Infrared Spectrometer for  
 the Infrared Telescope in Space  
 440-63-44 W93-70300  
 Two-Phase Nebulae  
 452-22-93 W93-70304  
**INJECTION LASERS**  
 Information and Controls Research and Technology  
 506-59-00 W93-70091  
**INJECTORS**  
 Earth-to-Orbit Transportation  
 584-03-00 W93-70121  
**INNER RADIATION BELT**  
 Thermosphere-Ionosphere-Mesosphere-Magnetospheric  
 Interactions  
 432-48-00 W93-70294  
**INSOLATION**  
 Remote Sensing of Air-Sea Fluxes  
 578-12-19 W93-70426  
**INSPECTION**  
 Aging Aircraft  
 538-02-00 W93-70061  
 Automation and Robotics  
 586-02-00 W93-70130  
 Automation and Robotics  
 586-02-00 W93-70132  
 Automation and Robotics  
 586-02-00 W93-70133  
**INTAKE SYSTEMS**  
 Emissions and Source Noise  
 537-02-00 W93-70053  
**INTEGRATED CIRCUITS**  
 Space Energy Conversion Research and Technology  
 506-41-00 W93-70067  
 Information and Controls Research and Technology  
 506-59-00 W93-70091  
 Information and Communications  
 586-03-00 W93-70135  
**INTEGRATED MISSION CONTROL CENTER**  
 Expert Systems for Automation of Operations  
 310-40-47 W93-70547  
**INTERACTIONS**  
 Forest/Climate Interactions  
 462-21-00 W93-70337

**INTERFACIAL TENSION**

- In-Space Technology Experiments  
506-74-00 W93-70107
- Glasses and Ceramics  
674-26-08 W93-70516

**INTERFEROMETERS**

- Materials and Structures Research and Technology  
506-43-00 W93-70075
- Information and Controls Research and Technology  
506-59-00 W93-70091
- Science Sensing (Remote)  
582-03-00 W93-70111
- Observatory Systems  
582-04-00 W93-70114
- Observatory Systems  
582-04-00 W93-70115
- Optical Stellar Interferometry  
188-41-21 W93-70184
- Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185
- Gravity Wave Mission Definition Study  
188-78-01 W93-70212
- Optical Interferometry in Space  
188-78-41 W93-70213
- Airborne Interferometric Topography  
462-74-01 W93-70350
- IR Solar Absorption Spectra  
464-12-05 W93-70368
- Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380
- Airborne Interferometric Topography  
465-67-04 W93-70419
- ASF SAR Interferometry  
665-35-01 W93-70500

**INTERFEROMETRY**

- Science Sensing (Remote)  
582-03-00 W93-70110
- Optical Stellar Interferometry  
188-41-21 W93-70184
- Global Assessment of Active Volcanism  
429-81-95 W93-70286
- Airborne Interferometric Topography  
462-74-01 W93-70350
- Theory of Geodetic Transformations  
465-15-06 W93-70398
- ASF SAR Interferometry  
665-35-01 W93-70500
- Astrometric Development Technology  
310-10-60 W93-70529

**INTERMETALLICS**

- Materials and Structures Research and Technology  
505-63-00 W93-70007

**INTERNATIONAL COOPERATION**

- Mars Data Analysis  
155-20-00 W93-70164
- Mars 94 Gravity  
155-20-03 W93-70167
- Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)  
428-81-10 W93-70263
- GEWEX Program Support  
461-50-03 W93-70331
- Soil Moisture from SAR  
462-62-05 W93-70349
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426

**INTERNATIONAL SUN EARTH EXPLORER 3**

- Cosmic and Heliospheric Physics  
170-10-10 W93-70177

**INTERNATIONAL SUN EARTH EXPLORERS**

- Cosmic and Heliospheric Physics  
170-10-10 W93-70176
- Cosmic and Heliospheric Physics  
170-10-10 W93-70177

**INTERPLANETARY DUST**

- Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- Two-Phase Nebulae  
452-22-93 W93-70304

**INTERPLANETARY FLIGHT**

- Planetary Instrument Development Program/Planetary  
Astronomy High Temperature Superconductor  
Bolometers  
157-05-50 W93-70175

**INTERPLANETARY GAS**

- Cosmic and Heliospheric Physics  
170-10-10 W93-70177

**INTERPLANETARY MAGNETIC FIELDS**

- Imaging Studies of Comets  
196-41-52 W93-70219

**INTERPLANETARY SPACECRAFT**

- Space Energy Conversion Research and Technology  
506-41-00 W93-70067
- Propulsion Research and Technology  
506-42-00 W93-70068

- Cosmic and Heliospheric Physics  
170-10-10 W93-70177
- Optical Communications Technology Development  
310-20-67 W93-70541

**INTERSTELLAR CHEMISTRY**

- Properties of Interstellar PAH's  
188-44-57 W93-70202
- Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245
- Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- Energetics of Interstellar Clouds  
399-20-00 W93-70257
- Origins of Solar Systems  
452-23-94 W93-70305

**INTERSTELLAR EXTINCTION**

- Energetics of Interstellar Clouds  
399-20-00 W93-70257

**INTERSTELLAR GAS**

- Laboratory Astrophysics  
188-44-57 W93-70201

**INTERSTELLAR MAGNETIC FIELDS**

- Cosmic and Heliospheric Physics  
170-10-10 W93-70176

**INTERSTELLAR MATTER**

- A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143
- Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145
- Chemical Kinetics and Spectroscopy of Planetary  
Molecules and Radicals  
154-75-80 W93-70159
- UV Astronomy and Data Systems  
188-41-51 W93-70189
- Submillimeter Astronomy  
188-44-23 W93-70194
- Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199
- Properties of Interstellar PAH's  
188-44-57 W93-70202
- High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210
- Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245
- Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- Energetics of Interstellar Clouds  
399-20-00 W93-70257
- Center for Star Formation Studies  
399-20-01 W93-70260
- The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons  
399-50-00 W93-70261
- Origins of Solar Systems  
452-23-94 W93-70305
- Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306

**INVENTORIES**

- Early Mars: Impact Basins, Crustal Dichotomy, Volcanic  
Resurfacing  
151-02-00 W93-70140
- Science Digital Data Preservation  
656-61-07 W93-70482

**INVERSIONS**

- Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348

**INVERTEBRATES**

- Structural Biosystems  
199-40-42 W93-70242

**INVISCID FLOW**

- Glasses and Ceramics  
674-26-08 W93-70516

**ION ACCELERATORS**

- Propulsion Research and Technology  
506-42-00 W93-70070

**ION BEAMS**

- Solar Physics Studies  
170-38-53 W93-70181

**ION ENGINES**

- Propulsion Research and Technology  
506-42-00 W93-70070

**ION PROPULSION**

- Propulsion Research and Technology  
506-42-00 W93-70070

**IONIC REACTIONS**

- Laboratory Astrophysics  
188-44-57 W93-70201

**IONIZATION**

- Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147

**IONIZING RADIATION**

- Materials and Structures Research and Technology  
506-43-00 W93-70076
- Science Sensing (Remote)  
582-03-00 W93-70109
- Radiation Health  
199-04-11 W93-70226

**IONOSPHERIC STORMS**

- Thermosphere-Ionosphere-Mesosphere-Magnetospheric  
Interactions  
432-48-00 W93-70294

**IONS**

- In-Space Experiments  
506-74-00 W93-70102
- Properties of Interstellar PAH's  
188-44-57 W93-70202
- Origins of Solar Systems  
452-23-94 W93-70305

**IRAS-ARAKI-ALCOCK COMET**

- Imaging Studies of Comets  
196-41-52 W93-70219

**IRON OXIDES**

- Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217

**IRRADIANCE**

- Solar Physics Studies  
170-38-53 W93-70181
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357

**IRRADIATION**

- Laboratory Astrophysics  
188-44-57 W93-70203

**ISCCP PROJECT**

- Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274
- Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315
- An Integrated Study of Surface Property Variations  
578-12-02 W93-70425

**ISOTHERMAL LAYERS**

- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426

**ISOTOPES**

- A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143
- Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145
- Planetary Materials: Geochronology  
152-14-40 W93-70146
- Cosmic and Heliospheric Physics  
170-10-10 W93-70176
- Energetics of Interstellar Clouds  
399-20-00 W93-70257

**ISOTOPIC LABELING**

- Laboratory Astrophysics  
188-44-57 W93-70203

**ITALY**

- Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320

**J****JAPANESE SPACECRAFT**

- The Development of a Mid-Infrared Spectrometer for  
the Infrared Telescope in Space  
440-63-44 W93-70300

**JET AIRCRAFT NOISE**

- Emissions and Source Noise  
537-02-00 W93-70053
- Emissions and Source Noise  
537-02-00 W93-70055

**JET ENGINES**

- Enabling Propulsion Materials  
537-04-00 W93-70058

**JET EXHAUST**

- Propulsion and Power  
505-62-00 W93-70005

**JET PROPULSION**

- Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429

**JOSEPHSON JUNCTIONS**

- Science Sensing (Remote)  
582-03-00 W93-70112

- High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210

**JUPITER (PLANET)**

- Ground-Based Infrared Astronomy  
196-41-50 W93-70218

**JUPITER ATMOSPHERE**

Magnetospheric Coupling  
432-36-00 W93-70293

**K****KALMAN FILTERS**

Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

**KERNEL FUNCTIONS**

Expert Systems for Automation of Operations  
310-40-47 W93-70547

**KINEMATICS**

Active Deformation in the Mojave Desert and Walker  
Lane: A Global Positioning System Experiment  
465-13-06 W93-70392  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438  
ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502

**KINETIC ENERGY**

Thermosphere-Ionosphere-Mesosphere-Magnetospheric  
Interactions  
432-48-00 W93-70294

**KINETICS**

Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376

**KNOWLEDGE BASES (ARTIFICIAL INTELLIGENCE)**

Automation and Robotics  
586-02-00 W93-70127  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70131  
DataHub - Knowledge-Based Assistance for Science  
Visualization and Analysis Using Large Distributed  
Databases  
656-65-21 W93-70492

**KOHOUTEK COMET**

Imaging Studies of Comets  
196-41-52 W93-70219

**KRYPTON**

Space Flight Research and Technology  
506-48-00 W93-70080

**KUIPER AIRBORNE OBSERVATORY**

Submillimeter Astronomy  
188-44-23 W93-70194  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Stratospheric Observatory for Infrared Astronomy  
(SOFIA)  
188-78-60 W93-70216  
Advanced Infrared Astronomy  
196-41-54 W93-70220

**L****LABORATORIES**

Planetary Materials: General Operations and Laboratory  
Facilities  
152-30-40 W93-70150  
Laboratory Astrophysics  
188-44-57 W93-70201  
Airborne Science Management Operating Working  
Group Support  
465-66-00 W93-70418  
Hydrospheric Processes Program Support for Modeling  
and Data Analysis  
578-97-12 W93-70446  
Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517

**LABORATORY EQUIPMENT**

Space Communications Research and Technology  
506-72-00 W93-70099  
Planetary Materials: General Operations and Laboratory  
Facilities  
152-30-40 W93-70150  
Flight Research  
199-40-72 W93-70244  
Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517

**LAGEOS (SATELLITE)**

Geopotential Temporal Variations  
465-17-02 W93-70400

**LAKES**

Telepresence for Planetary Exploration  
186-06-01 W93-70182  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
462-75-62 W93-70351  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Topography from SEASAT and GEOSAT Overland  
Altimetry  
579-42-03 W93-70469

**LAMINAR BOUNDARY LAYER**

Aerodynamics Research and Technology  
505-59-00 W93-70003  
Community Noise and Sonic Boom  
537-03-00 W93-70056

**LAMINAR FLOW**

High-Performance Flight Research  
533-02-00 W93-70041  
Community Noise and Sonic Boom  
537-03-00 W93-70057

**LAMINATES**

Advanced Composite Materials Technology  
510-02-00 W93-70037

**LAND ICE**

Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445  
Radar-Altimeter Ice Data System  
578-97-20 W93-70448

**LAND USE**

Biogeochemical Research in Tropical Ecosystems:  
Mechanisms of Trace Gas Production  
463-61-00 W93-70361

**LANDING SITES**

Exploration Exobiology  
199-52-82 W93-70251

**LANDSAT SATELLITES**

Foreign Visitor Support  
429-97-04 W93-70290  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408  
Remote Sensing of Active and Recently Active Volcanic  
Features  
465-44-01 W93-70411  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
Landsat Land Cover Pathfinder  
579-98-00 W93-70476

**LARGE DEPLOYABLE REFLECTOR**

Science Sensing (Remote)  
582-03-00 W93-70111  
Science Sensing (Remote)  
582-03-00 W93-70112  
Observatory Systems  
582-04-00 W93-70114  
Observatory Systems  
582-04-00 W93-70115

**LARGE SCALE INTEGRATION**

Micro Weather Stations for Mars  
157-04-80 W93-70174  
Data Storage Technology  
310-40-48 W93-70548

**LARGE SPACE STRUCTURES**

Materials and Structures Research and Technology  
506-43-00 W93-70072  
Materials and Structures Research and Technology  
506-43-00 W93-70075  
Information and Controls Research and Technology  
506-59-00 W93-70089  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
Automation and Robotics  
586-02-00 W93-70129  
Airborne ESTAR  
461-38-01 W93-70327  
Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338  
Validation of Volcanic Plume Models with Remote  
Sensing  
465-44-04 W93-70413  
Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537  
Antenna Systems Development  
310-20-65 W93-70539

**LASER ALTIMETERS**

Science Sensing (Remote)  
582-03-00 W93-70111  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172

**LASER APPLICATIONS**

Flight Systems Research and Technology  
505-68-00 W93-70013  
Science Sensing (Remote)  
582-03-00 W93-70110  
Science Sensing (Remote)  
582-03-00 W93-70111  
Science Sensing (Remote)  
582-03-00 W93-70113  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172  
Theory of Geodetic Transformations  
465-15-06 W93-70398  
Advanced Magnetometer  
465-31-01 W93-70404  
Optical Communications  
310-20-35 W93-70533  
Optical Communications Technology Development  
310-20-67 W93-70541

**LASER BEAMS**

Optical Interferometry in Space  
188-78-41 W93-70213  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523

**LASER DOPPLER VELOCIMETERS**

Earth-To-Orbit Transportation  
584-03-00 W93-70119

**LASER INDUCED FLUORESCENCE**

Laser Induced Fluorescence: A Technique for Remote  
Assessment of Photosynthetic Efficiency and Detection  
of Environmental Stress  
462-31-63 W93-70339

**LASER INTERFEROMETRY**

Gravity Wave Mission Definition Study  
188-78-01 W93-70212  
Optical Interferometry in Space  
188-78-41 W93-70213

**LASER MATERIALS**

Science Sensing (Remote)  
582-03-00 W93-70110

**LASER OUTPUTS**

Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358

**LASER PUMPING**

Advanced Magnetometer  
465-31-01 W93-70404

**LASER RANGE FINDERS**

Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
Global Tectonic Motions  
465-14-01 W93-70394  
Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395  
Lateral Variations in Solid Tides  
465-17-04 W93-70401  
Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459  
Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

**LASER SPECTROMETERS**

Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172  
Advanced Infrared Astronomy  
196-41-54 W93-70220  
CO2 Lidar Backscatter Experiment  
460-21-00 W93-70309  
Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

**LASER SPECTROSCOPY**

Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156  
Laser Diode Sensor  
464-11-07 W93-70366  
Laser Laboratory Spectroscopy  
464-23-09 W93-70382

**LASER TARGETS**

Lidar Target Calibration Facility  
460-22-52 W93-70312  
Wind Measurement Assessment  
460-28-41 W93-70314

**LASERS**

Space Communications Research and Technology  
506-72-00 W93-70099  
Information and Communications  
586-03-00 W93-70135



- Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)  
157-03-90 W93-70173
- Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190
- LATE STARS**  
Submillimeter Astronomy  
188-44-23 W93-70194
- LATENT HEAT**  
IR Remote Sensing of SST  
460-21-28 W93-70310
- Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis  
578-10-00 W93-70421
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426
- Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
578-40-00 W93-70441
- LATITUDE**  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408
- Neptune Data Analysis  
889-59-00 W93-70525
- LAUNCH VEHICLES**  
Hypersonic Research and Technology  
505-70-00 W93-70023
- Propulsion Research and Technology  
506-42-00 W93-70068
- Hypersonic Research and Technology  
506-73-00 W93-70101
- Earth-to-Orbit Transportation  
584-03-00 W93-70120
- Automation and Robotics  
586-02-00 W93-70133
- Integral Mission Definition Study  
188-78-01 W93-70211
- The Development of a Mid-Infrared Spectrometer for the Infrared Telescope in Space  
440-63-44 W93-70300
- LAUNCHERS**  
Optical Interferometry in Space  
188-78-41 W93-70213
- LAUNCHING**  
Automation and Robotics  
586-02-00 W93-70133
- Optical Interferometry in Space  
188-78-41 W93-70213
- LAUNCHING SITES**  
AVIRIS Operations  
463-75-63 W93-70364
- LAVA**  
Global Assessment of Active Volcanism  
428-81-94 W93-70269
- Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411
- Evolution of Volcanic Terrains  
465-44-02 W93-70412
- Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416
- LEADERSHIP**  
Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317
- LEADING EDGES**  
Hypersonic Training and Research  
505-70-00 W93-70021
- LEAF AREA INDEX**  
Forest/Climate Interactions  
462-21-00 W93-70337
- LEAST SQUARES METHOD**  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458
- LEAVES**  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346
- LECTURES**  
GEWEX Program Support  
461-50-03 W93-70331
- LEG (ANATOMY)**  
Musculoskeletal  
199-26-14 W93-70238
- LESIONS**  
Space Radiation  
199-04-14 W93-70228
- LIBRARIES**  
Oceanic Remote Sensing Library  
461-66-16 W93-70335
- Thermal Infrared Science Support  
462-75-74 W93-70352
- Radar-Altimeter Ice Data System  
578-97-20 W93-70448
- Planetary Hardcopy Preservation Task  
656-61-20 W93-70486
- LIFE (DURABILITY)**  
Materials and Structures Research and Technology  
505-63-00 W93-70008
- Materials and Structures Research and Technology  
505-63-00 W93-70009
- Advanced High Temperature Engine Materials  
510-01-00 W93-70036
- Enabling Propulsion Materials  
537-04-00 W93-70058
- Space Energy Conversion Research and Technology  
506-41-00 W93-70067
- LIFE CYCLE COSTS**  
Data Storage Technology  
310-40-48 W93-70548
- LIFE SCIENCES**  
Systems Analysis  
506-49-00 W93-70085
- Automation and Robotics  
586-02-00 W93-70127
- General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232
- Flight Research  
199-40-72 W93-70244
- Data System Integration (Commonality and Interoperability)  
656-61-02 W93-70478
- SS Freedom Archive Planning Study  
656-61-13 W93-70483
- LIFE SUPPORT SYSTEMS**  
Human Support Research and Technology  
506-71-00 W93-70093
- Human Support Research and Technology  
506-71-00 W93-70095
- In-Space Experiments  
506-74-00 W93-70102
- In-Space Technology Experiments  
506-74-00 W93-70107
- LIFT**  
High-Performance Flight Research  
533-02-00 W93-70043
- LIGAMENTS**  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- LIGHT (VISIBLE RADIATION)**  
Science Sensing (Remote)  
582-03-00 W93-70110
- Solar Physics Studies  
170-38-53 W93-70181
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- LIGHT MODULATION**  
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495
- LIGHT SCATTERING**  
Materials and Structures Research and Technology  
506-43-00 W93-70075
- Microgravity Nucleation and Particle Coagulation Experiments  
152-20-01 W93-70148
- IR Astronomy ATD/Cryo Optical Testing and Science Support Activities  
188-78-44 W93-70214
- Optical Scattering of Plant Canopies  
462-61-00 W93-70346
- Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- LIGHTNING**  
Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160
- Neptune Data Analysis  
889-59-00 W93-70525
- LINE SPECTRA**  
Deep Optical/UV Imaging of Quasars Below the Lyman Limit  
188-41-21 W93-70183
- Submillimeter Astronomy  
188-44-23 W93-70194
- Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370
- Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383
- Measurement of Volcanic Gases  
465-44-05 W93-70414
- LINEAR ENERGY TRANSFER (LET)**  
Materials and Structures Research and Technology  
506-43-00 W93-70076
- Space Radiation  
199-04-14 W93-70228
- LIPIDS**  
The Early Evolution of Life  
199-52-32 W93-70248
- LIQUID HELIUM**  
Observatory Systems  
582-04-00 W93-70115
- IR Astronomy ATD/Cryo Optical Testing and Science Support Activities  
188-78-44 W93-70214
- LIQUID PROPELLANT ROCKET ENGINES**  
Earth-To-Orbit Transportation  
584-03-00 W93-70119
- Earth-to-Orbit Transportation  
584-03-00 W93-70120
- LIQUID ROCKET PROPELLANTS**  
Earth-to-Orbit Transportation  
584-03-00 W93-70121
- LIQUID SLOSHING**  
In-Space Experiments  
506-74-00 W93-70105
- LITERATURE**  
NSSDC Astrophysics Data Systems Support  
656-61-17 W93-70484
- LITHIUM ALLOYS**  
Earth-to-Orbit Transportation  
584-03-00 W93-70120
- LITHOSPHERE**  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140
- Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409
- LOADS (FORCES)**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036
- LOCAL AREA NETWORKS**  
A 4D Data Assimilation for EOS Computer Support  
428-81-04 W93-70262
- Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450
- Networks Communication Technology  
310-20-38 W93-70536
- LOCOMOTION**  
Neuroscience (Biomedical)  
199-16-12 W93-70234
- LONG DURATION EXPOSURE FACILITY**  
Materials and Structures Research and Technology  
506-43-00 W93-70076
- Materials and Structures Research and Technology  
506-43-00 W93-70077
- Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246
- LONG DURATION SPACE FLIGHT**  
Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers  
157-05-50 W93-70175
- Clinical Medicine Technology Watch  
199-02-31 W93-70223
- LONGITUDE**  
Neptune Data Analysis  
889-59-00 W93-70525
- LOSSES**  
Solar Physics Studies  
170-38-53 W93-70181
- LOW COST**  
Optical Interferometry in Space  
188-78-41 W93-70213
- Interdisciplinary ATD Studies  
433-04-00 W93-70295
- Sounding Rockets: Space Plasma Physics Experiments  
435-11-00 W93-70298
- Advanced Search and Rescue Techniques  
669-30-10 W93-70504
- Data Storage Technology  
310-40-48 W93-70548
- LOW DENSITY FLOW**  
Hypersonics Research and Technology  
506-73-00 W93-70100
- LOW GRAVITY MANUFACTURING**  
Biotechnology  
674-23-08 W93-70509
- LOW NOISE**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039
- Advanced Turboprop Systems  
535-03-00 W93-70044
- X-Ray Astronomy CCD  
188-46-59 W93-70209
- Airborne Interferometric Topography  
462-74-01 W93-70350
- LOW TEMPERATURE**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066
- Space Energy Conversion Research and Technology  
506-41-00 W93-70067

Global Assessment of Active Volcanism  
429-81-97 W93-70288

**LOW THRUST PROPULSION**  
Propulsion Research and Technology  
506-42-00 W93-70068

**LOWER ATMOSPHERE**  
Mars 94 Winds  
155-20-04 W93-70168  
IDS Science for WHOI/GSFC Eos Project:  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284

**LOWER CALIFORNIA (MEXICO)**  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408

**LOWER IONOSPHERE**  
Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298

**LUBRICATION**  
Materials and Structures Research and Technology  
506-43-00 W93-70073

**LUMINESCENCE**  
In-Space Technology Experiments  
506-74-00 W93-70107

**LUNAR BASES**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
In-Space Experiments  
506-74-00 W93-70105  
Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226

**LUNAR EXPLORATION**  
Exploration Exobiology  
199-52-82 W93-70251  
Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253

**LUNAR GEOLOGY**  
Planetary Materials: Collection, Preservation and  
Distribution  
152-20-40 W93-70149

**LUNAR GRAVITATIONAL EFFECTS**  
Theory of Geodetic Transformations  
465-15-06 W93-70398

**LUNAR ORBITER**  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172

**LUNAR ROCKS**  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Planetary Materials: Collection, Preservation and  
Distribution  
152-20-40 W93-70149

**LUNAR SOIL**  
Planetary Materials: Collection, Preservation and  
Distribution  
152-20-40 W93-70149

**LUNAR SURFACE**  
Science Sensing (Remote)  
582-03-00 W93-70111  
Telepresence for Planetary Exploration  
186-06-01 W93-70182

**LUNAR TOPOGRAPHY**  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172

**LYMAN ALPHA RADIATION**  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

**LYMAN SPECTRA**  
Deep Optical/UV Imaging of Quasars Below the Lyman  
Limit  
188-41-21 W93-70183

## M

**MACH NUMBER**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063

**MACHINE LEARNING**  
Information and Controls Research and Technology  
506-59-00 W93-70088

**MACHINING**  
Micro Weather Stations for Mars  
157-04-80 W93-70174

**MAGMA**  
Global Assessment of Active Volcanism  
428-81-96 W93-70270

**MAGNETIC ANOMALIES**  
Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405

**MAGNETIC CORES**  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

**MAGNETIC DIFFUSION**  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

**MAGNETIC DISKS**  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459

**MAGNETIC FIELD CONFIGURATIONS**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177

**MAGNETIC FIELD RECONNECTION**  
Imaging Studies of Comets  
196-41-52 W93-70219

**MAGNETIC FIELDS**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180  
Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195  
Thermosphere-Ionosphere-Mesosphere-Magnetospheric  
Interactions  
432-48-00 W93-70294  
Advanced Magnetometer  
465-31-01 W93-70404  
Problems in Interpreting Satellite Crustal Anomaly Field  
Data  
579-31-01 W93-70456  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

**MAGNETIC MATERIALS**  
Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148

**MAGNETIC PROPERTIES**  
Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148  
Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405

**MAGNETIC RESONANCE**  
Musculoskeletal  
199-26-14 W93-70238

**MAGNETIC SIGNATURES**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179

**MAGNETIC SPECTROSCOPY**  
Space Flight Research and Technology  
506-48-00 W93-70080

**MAGNETIC SURVEYS**  
Problems in Interpreting Satellite Crustal Anomaly Field  
Data  
579-31-01 W93-70456

**MAGNETIC TAPES**  
Science Digital Data Preservation  
656-61-07 W93-70482

**MAGNETIC VARIATIONS**  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457

**MAGNETOHYDRODYNAMIC FLOW**  
Fluid Physics  
674-24-05 W93-70511

**MAGNETOHYDRODYNAMIC WAVES**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177

**MAGNETOHYDRODYNAMICS**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199

**MAGNETOMETERS**  
Advanced Magnetometer  
465-31-01 W93-70404  
Neptune Data Analysis  
889-59-00 W93-70524

**MAGNETOPOUSE**  
Neptune Data Analysis  
889-59-00 W93-70524

**MAGNETOSPHERE-IONOSPHERE COUPLING**  
Solar Wind-Magnetosphere-Ionosphere Coupling,  
Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292

**MAGSAT SATELLITES**  
Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405

**MAIN SEQUENCE STARS**  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197  
Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301

**MAINTAINABILITY**  
GA/Commuter Engine Technology  
535-05-00 W93-70046

**MAINTENANCE**  
Automation and Robotics  
586-02-00 W93-70129  
Automation and Robotics  
586-02-00 W93-70132  
AVIRIS Operations  
463-75-63 W93-70364  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Goldstone DOSE Support  
465-28-02 W93-70403  
AVIRIS Operations  
465-65-01 W93-70417  
NSSDC Astrophysics Data Systems Support  
656-61-17 W93-70484

**MAMMALS**  
Cell and Developmental Biology  
199-40-22 W93-70240

**MAN ENVIRONMENT INTERACTIONS**  
EOS IDS, EOSDIS Money  
428-81-36 W93-70266  
EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280  
Laser Diode Sensor  
464-11-07 W93-70366  
MM and Sub-MM Radiometry  
464-12-06 W93-70369  
Climatological Stratospheric Modeling  
579-24-09 W93-70455

**MAN MACHINE SYSTEMS**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
Automation and Robotics  
586-02-00 W93-70130  
Telepresence for Planetary Exploration  
186-06-01 W93-70182  
Space Human Factors Behavior and Performance  
199-06-11 W93-70229  
Exploration Exobiology  
199-52-82 W93-70251  
Human-to-Machine Interface Technology  
310-40-37 W93-70545

**MAN-COMPUTER INTERFACE**  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488  
Graphical Methods for Science Visualization and Data  
Analysis  
656-65-05 W93-70489  
Construction of an Advanced Software Tool for Planetary  
Atmospheric Modeling  
656-65-24 W93-70494  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534  
Human-to-Machine Interface Technology  
310-40-37 W93-70545

**MANAGEMENT**  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70012  
LTP Computer Support  
579-41-04 W93-70465

**MANAGEMENT INFORMATION SYSTEMS**  
A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496

**MANAGEMENT METHODS**  
Windows on Global Change  
665-82-03 W93-70503

**MANAGEMENT PLANNING**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Ocean Color Data System  
428-82-06 W93-70272  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
465-68-01 W93-70420  
PDS: Data Distribution and Archive Technology  
656-61-06 W93-70481

**MANAGEMENT SYSTEMS**

- Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059
- Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060
- Information and Controls Research and Technology  
506-59-00 W93-70090
- Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480
- Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498
- Advanced Environments for Software and System Development  
310-40-49 W93-70549

**MANEUVERABILITY**

- Flight Systems Research and Technology  
505-68-00 W93-70015

**MANIPULATORS**

- Information and Controls Research and Technology  
506-59-00 W93-70092
- Automation and Robotics  
586-02-00 W93-70132

**MANNED MANEUVERING UNITS**

- Information and Controls Research and Technology  
506-59-00 W93-70092

**MANNED MARS MISSIONS**

- In-Space Experiments  
506-74-00 W93-70105

**MANNED SPACE FLIGHT**

- Micro Weather Stations for Mars  
157-04-80 W93-70174
- Ground-Based Support of Solar Physics  
170-38-52 W93-70179
- Clinical Medicine Technology Watch  
199-02-31 W93-70223
- Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225
- Behavior and Performance Research  
199-06-11 W93-70230
- General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232
- Cardiopulmonary Physiology  
199-14-12 W93-70233
- Regulatory Physiology (Biomedical)  
199-18-12 W93-70235
- Advanced Transmitter Systems Development  
310-20-64 W93-70538

**MANNED SPACECRAFT**

- Environmental Health  
199-04-11 W93-70227

**MANPOWER**

- Consulting and Program Support  
674-29-08 W93-70520

**MANUALS**

- Propulsion Research and Technology  
506-42-00 W93-70069

**MANUFACTURING**

- Earth-to-Orbit Transportation  
584-03-00 W93-70120

**MAPPING**

- U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166
- Airborne Interferometric Topography  
462-74-01 W93-70350
- Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408
- Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409
- Airborne Interferometric Topography  
465-67-04 W93-70419
- Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439

**MAPS**

- Global Monthly Mean Ocean Variability  
578-22-29 W93-70435

**MARINE METEOROLOGY**

- IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- Radiative Effects in Clouds First International Satellite Cloud Climatology Regional Experiment  
460-42-00 W93-70315
- Experimental Cloud Analysis Techniques  
578-12-01 W93-70424
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426

**MARINER 7 SPACE PROBE**

- Mars Atmosphere Dust Opacity  
155-04-00 W93-70163

**MARINER 9 SPACE PROBE**

- U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166

**MARKET RESEARCH**

- Systems Analysis  
505-69-00 W93-70019

**MARS (PLANET)**

- Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140
- Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141
- Planetary Materials: Experimental Petrology  
152-12-40 W93-70142
- Planetary Materials: Chemistry  
152-13-40 W93-70144
- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151
- Planetary Clouds Particulates and Ices  
154-30-80 W93-70155
- Mars Data Analysis  
155-20-00 W93-70164
- U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166
- Mars 94 Gravity  
155-20-03 W93-70167
- Telepresence for Planetary Exploration  
186-06-01 W93-70182
- Exploration Exobiology  
199-52-82 W93-70251

**MARS ATMOSPHERE**

- Dynamics of Planetary Atmospheres  
154-20-80 W93-70153
- Planetary Clouds Particulates and Ices  
154-30-80 W93-70155
- Mars 3-D Global Circulation Model  
154-95-80 W93-70161
- Mars Surface and Atmosphere Studies  
155-04-00 W93-70162
- Mars Atmosphere Dust Opacity  
155-04-00 W93-70163
- Planetary Data System  
155-20-00 W93-70165
- Mars 94 Gravity  
155-20-03 W93-70167
- Mars 94 Winds  
155-20-04 W93-70168
- Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)  
157-03-90 W93-70173
- Micro Weather Stations for Mars  
157-04-80 W93-70174

**MARS ENVIRONMENT**

- Exploration Exobiology  
199-52-82 W93-70251

**MARS LANDING**

- Planetary Data System  
155-20-00 W93-70165
- Exploration Exobiology  
199-52-82 W93-70251

**MARS OBSERVER**

- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151
- Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)  
157-03-90 W93-70173
- High Energy Astrophysics International Programs  
440-62-59 W93-70299
- Network Signal Processing  
310-30-70 W93-70543

**MARS PROBES**

- Mars 94 Gravity  
155-20-03 W93-70167

**MARS SATELLITES**

- Mars 94 Gravity  
155-20-03 W93-70167

**MARS SURFACE**

- Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140
- Planetary Clouds Particulates and Ices  
154-30-80 W93-70155
- Mars Surface and Atmosphere Studies  
155-04-00 W93-70162
- Mars Atmosphere Dust Opacity  
155-04-00 W93-70163
- U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166
- Mars 94 Gravity  
155-20-03 W93-70167

- Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)  
157-03-90 W93-70173

**MARS SURFACE SAMPLES**

- Two-Phase Nebulae  
452-22-93 W93-70304
- Micro Weather Stations for Mars  
157-04-80 W93-70174
- Telepresence for Planetary Exploration  
186-06-01 W93-70182
- Windows on Global Change  
665-82-03 W93-70503

**MARS SURFACE SAMPLES**

- Two-Phase Nebulae  
452-22-93 W93-70304

**MARSHLANDS**

- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360

**MASER OUTPUTS**

- Frequency and Timing Research  
310-10-62 W93-70531

**MASERS**

- Frequency and Timing Research  
310-10-62 W93-70531
- Radio Systems Development  
310-20-66 W93-70540

**MASS DISTRIBUTION**

- Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416

**MASS SPECTROMETERS**

- Space Flight Research and Technology  
506-48-00 W93-70080
- Human Support Research and Technology  
506-71-00 W93-70093
- Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals  
154-75-80 W93-70159
- Planetary Instrument Definition and Development  
157-03-50 W93-70169
- Magnetospheric Coupling  
432-36-00 W93-70293

**MASS SPECTROSCOPY**

- Human Support Research and Technology  
506-71-00 W93-70093
- A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains  
152-12-40 W93-70143
- Planetary Materials: Geochronology  
152-14-40 W93-70146
- Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376
- Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386

**MASS TRANSFER**

- Propulsion Research and Technology  
506-42-00 W93-70068
- Fluid Physics  
674-24-08 W93-70512

**MASSIVELY PARALLEL PROCESSORS**

- Computational Aerosciences  
509-10-00 W93-70030
- Computational/Aeroscience  
509-10-00 W93-70031
- Earth and Space Sciences  
509-20-00 W93-70034
- Advanced Programs Theoretical Biology  
199-55-19 W93-70252

**MATERIALS SCIENCE**

- Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517

**MATERIALS TESTS**

- Biotechnology  
674-23-08 W93-70509

**MATHEMATICAL MODELS**

- Applied Aerodynamics Research and Technology  
505-59-00 W93-70001
- Computational Aerosciences  
509-10-00 W93-70029
- Computational Aerosciences  
509-10-00 W93-70030
- Computational/Aeroscience  
509-10-00 W93-70031
- Earth and Space Sciences  
509-20-00 W93-70034
- Emissions and Source Noise  
537-02-00 W93-70053
- Space Energy Conversion Research and Technology  
506-41-00 W93-70066
- Propulsion Research and Technology  
506-42-00 W93-70069
- Materials and Structures Research and Technology  
506-43-00 W93-70076
- Space Flight Research and Technology  
506-48-00 W93-70080
- Automation and Robotics  
586-02-00 W93-70127
- Solar System Studies  
151-01-60 W93-70138

- Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141
- Planetary Materials: Experimental Petrology  
152-12-40 W93-70142
- Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145
- Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158
- Planetary Lightning and Analysis of Voyager  
Observations  
154-90-80 W93-70160
- Mars 3-D Global Circulation Model  
154-95-80 W93-70161
- Mars Lidar (Lidar from the Mars Surface and Mars Orbit  
for Atmospheric Studies)  
157-03-90 W93-70173
- Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188
- Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199
- Theory and Modeling: Infrared, Submillimeter, and  
Radio  
188-44-53 W93-70200
- Laboratory Astrophysics  
188-44-57 W93-70201
- Optical Interferometry in Space  
188-78-41 W93-70213
- Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217
- Advanced Infrared Astronomy  
196-41-54 W93-70220
- Energetics of Interstellar Clouds  
399-20-00 W93-70257
- Space Physics Theory Program  
431-06-00 W93-70291
- Solar Wind-Magnetosphere-Ionosphere Coupling,  
Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292
- Magnetospheric Coupling  
432-36-00 W93-70293
- Planet-Forming Disks  
452-21-93 W93-70302
- Two-Phase Nebulae  
452-22-93 W93-70304
- Origins of Solar Systems  
452-23-94 W93-70305
- Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348
- Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388
- Theory of Geodetic Transformations  
465-15-06 W93-70398
- Geopotential Temporal Variations  
465-17-02 W93-70400
- Remote Sensing of Active and Recently Active Volcanic  
Features  
465-44-01 W93-70411
- Validation of Volcanic Plume Models with Remote  
Sensing  
465-44-04 W93-70413
- Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423
- Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430
- Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432
- JPL Oceanography Group Common Computer System  
578-22-27 W93-70434
- Global Climate Modeling  
578-41-01 W93-70442
- Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450
- Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451
- Simulation of Tropospheric Ozone  
579-24-00 W93-70453
- Climatological Stratospheric Modeling  
579-24-09 W93-70455
- Modeling of the Main Magnetic Field  
579-31-02 W93-70457
- Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458
- Core-Mantle Excitation  
579-36-11 W93-70463
- Fluid Physics  
674-24-00 W93-70510
- Sounding Rocket Experiments  
879-11-38 W93-70522
- Neptune Data Analysis  
889-59-00 W93-70525
- MATRIX MATERIALS**  
Materials and Structures Research and Technology  
505-63-00 W93-70007
- Advanced High Temperature Engine Materials  
510-01-00 W93-70036
- Advanced Composite Materials Technology  
510-02-00 W93-70038
- MAXIMUM LIKELIHOOD ESTIMATES**  
Retracking of Topex Waveform Data  
461-34-01 W93-70326
- MEASURING INSTRUMENTS**  
Mars 94 Winds  
155-20-04 W93-70168
- Laser Diode Sensor  
464-11-07 W93-70366
- Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383
- Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432
- MECHANICAL PROPERTIES**  
Materials and Structures Research and Technology  
505-63-00 W93-70008
- Materials and Structures Research and Technology  
506-43-00 W93-70076
- Earth-to-Orbit Transportation  
584-03-00 W93-70120
- MEDICAL EQUIPMENT**  
Clinical Medicine Technology Watch  
199-02-31 W93-70223
- MEDICAL SCIENCE**  
Clinical Medicine Technology Watch  
199-02-31 W93-70223
- Neuroscience (Biomedical)  
199-16-12 W93-70234
- MELTING**  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- ASF SAR Interferometry  
665-35-01 W93-70500
- Glasses and Ceramics  
674-26-08 W93-70516
- MELTS (CRYSTAL GROWTH)**  
Metals and Alloys  
674-25-08 W93-70514
- MEMBRANES**  
In-Space Experiments  
506-74-00 W93-70102
- MEMORY (COMPUTERS)**  
Information and Communications  
586-03-00 W93-70137
- MENTAL HEALTH**  
Behavior and Performance Research  
199-06-11 W93-70230
- MERCURY (PLANET)**  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217
- MERCURY CADMIUM TELLURIDES**  
Observatory Systems  
582-04-00 W93-70115
- MESOMETEOROLOGY**  
Scatterometer Studies  
461-31-13 W93-70324
- MESOSCALE PHENOMENA**  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316
- Desert Mesoscale/PBL  
461-13-02 W93-70322
- Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432
- MESOSPHERE**  
Thermosphere-Ionosphere-Mesosphere-Magnetospheric  
Interactions  
432-48-00 W93-70294
- Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452
- Climatological Stratospheric Modeling  
579-24-09 W93-70455
- METABOLISM**  
Space Radiation  
199-04-14 W93-70228
- METAL MATRIX COMPOSITES**  
Materials and Structures Research and Technology  
505-63-00 W93-70007
- Enabling Propulsion Materials  
537-04-00 W93-70058
- METALLURGY**  
Metals and Alloys  
674-25-08 W93-70514
- METALS**  
Materials and Structures Research and Technology  
505-63-00 W93-70008
- Metals and Alloys  
674-25-05 W93-70513
- Metals and Alloys  
674-25-08 W93-70514
- METEORITE COLLISIONS**  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222
- METEORITE CRATERS**  
Planetary Materials: Geochronology  
152-14-40 W93-70146
- METEORITES**  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141
- Planetary Materials: Experimental Petrology  
152-12-40 W93-70142
- Planetary Materials: Chemistry  
152-13-40 W93-70144
- Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147
- Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148
- Planetary Materials: Collection, Preservation and  
Distribution  
152-20-40 W93-70149
- Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245
- Solar System Exploration  
199-52-52 W93-70249
- Two-Phase Nebulae  
452-22-93 W93-70304
- Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306
- METEORITIC COMPOSITION**  
Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145
- Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148
- METEOROLOGICAL BALLOONS**  
Mars 94 Winds  
155-20-04 W93-70168
- Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370
- METEOROLOGICAL CHARTS**  
GPS/VLBI Vertical Measurement  
465-14-09 W93-70396
- METEOROLOGICAL INSTRUMENTS**  
NDSC Microwave Instrument Support  
464-13-22 W93-70372
- METEOROLOGICAL PARAMETERS**  
Planetary Data System  
155-20-00 W93-70165
- Micro Weather Stations for Mars  
157-04-80 W93-70174
- Interannual Variability of Global Cycles  
429-81-06 W93-70276
- EOS Science  
429-81-38 W93-70281
- Project to Interface Modeling  
429-81-72 W93-70283
- IDS Science for WHOI/GSFC Eos Project:  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- Atmospheric Backscatter Experiment  
460-22-53 W93-70313
- Wind Measurement Assessment  
460-28-41 W93-70314
- Scatterometer Studies  
461-31-13 W93-70324
- Heterogeneous Scene Models  
462-61-03 W93-70347
- NDSC Microwave Instrument Support  
464-13-22 W93-70372
- Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384
- Global Tropospheric Experiment Aircraft,  
Measurements  
464-54-00 W93-70387
- Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402
- Meteorological Parameters Extraction  
578-12-20 W93-70427
- Atmospheric Parameter Mapping  
578-12-21 W93-70428
- Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432
- Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438

- Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468
- METEOROLOGICAL RADAR**
- CO<sub>2</sub> Lidar Backscatter Experiment  
460-21-00 W93-70309
- Atmospheric Backscatter Experiment  
460-22-53 W93-70313
- Airborne Precipitation Radar  
461-51-16 W93-70332
- METEOROLOGICAL SATELLITES**
- Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
- METEOROLOGICAL SERVICES**
- Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450
- METEOROLOGY**
- Micro Weather Stations for Mars  
157-04-80 W93-70174
- Oceanic Remote Sensing Library  
461-66-16 W93-70335
- Forest/Climate Interactions  
462-21-00 W93-70337
- GPS/VLBI Vertical Measurement  
465-14-09 W93-70396
- Validation of Volcanic Plume Models with Remote  
Sensing  
465-44-04 W93-70413
- Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429
- A Distributed Analysis and Visualization System for  
Model and Observational Data  
656-65-27 W93-70497
- METHANE**
- Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359
- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- Biogeochemical Research in Tropical Ecosystems:  
Mechanisms of Trace Gas Production  
463-61-00 W93-70361
- Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386
- Simulation of Tropospheric Ozone  
579-24-00 W93-70453
- Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- Spatial and Temporal Distribution of Biomass  
Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472
- ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499
- METHYL COMPOUNDS**
- IDS Science for WHOI/GSFC Eos Project:  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- METROLOGY**
- Information and Controls Research and Technology  
506-59-00 W93-70091
- Science Sensing (Remote)  
582-03-00 W93-70113
- Astrometric Imaging Telescope  
157-03-70 W93-70171
- Optical Interferometry in Space  
188-78-41 W93-70213
- MEXICO**
- Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416
- MICHELSON INTERFEROMETERS**
- Optical Stellar Interferometry  
188-41-21 W93-70184
- MICHIGAN**
- Windows on Global Change  
665-82-03 W93-70503
- MICROANALYSIS**
- Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141
- MICROBIOLOGY**
- Environmental Health  
199-04-11 W93-70227
- MICROCHANNEL PLATES**
- Solar Physics Studies  
170-38-53 W93-70181
- MICROCLIMATOLOGY**
- Visiting Scientists  
462-76-49 W93-70353
- MICROELECTRONICS**
- Communication Systems Research  
310-30-71 W93-70544
- MICROGRAVITY APPLICATIONS**
- SS Freedom Archive Planning Study  
656-61-13 W93-70483
- Electronic Materials  
674-21-05 W93-70505
- Combustion Science  
674-22-05 W93-70507
- Biotechnology  
674-23-08 W93-70509
- Fluid Physics  
674-24-00 W93-70510
- Fluid Physics  
674-24-05 W93-70511
- Consulting and Program Support  
674-29-08 W93-70520
- MICROMECHANICS**
- Materials and Structures Research and Technology  
505-63-00 W93-70007
- MICROMETEOROIDS**
- Materials and Structures Research and Technology  
506-43-00 W93-70077
- MICROORGANISMS**
- Advanced Programs Theoretical Biology  
199-55-19 W93-70252
- Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253
- Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254
- MICROPROCESSORS**
- JPL Oceanography Group Common Computer System  
578-22-27 W93-70434
- MICROSTRUCTURE**
- Materials and Structures Research and Technology  
505-63-00 W93-70008
- Materials and Structures Research and Technology  
506-43-00 W93-70073
- Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306
- MICROWAVE ANTENNAS**
- Network Signal Processing  
310-30-70 W93-70543
- MICROWAVE ATTENUATION**
- ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- MICROWAVE EMISSION**
- Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341
- MICROWAVE EQUIPMENT**
- Information and Controls Research and Technology  
506-59-00 W93-70091
- MM and Sub-MM Radiometry  
464-12-06 W93-70369
- Optical Communications  
310-20-35 W93-70533
- MICROWAVE FREQUENCIES**
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Airborne Interferometric Topography  
462-74-01 W93-70350
- Airborne Interferometric Topography  
465-67-04 W93-70419
- Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- Frequency and Timing Research  
310-10-62 W93-70531
- MICROWAVE IMAGERY**
- Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282
- Validations of Passive Microwave Snow Water  
Equivalent Algorithm  
461-13-00 W93-70319
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321
- Altitude Measurements of Wind Speed and Sea Level  
Height With Applications to Air-Sea Interaction Studies:  
Physical Principles and Advanced Techniques  
461-33-02 W93-70325
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336
- Soil Moisture from SAR  
462-62-05 W93-70349
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
- Active/Passive Sea Ice Analysis  
578-32-24 W93-70437
- Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468
- Soil/Canopy Moisture and Temperature Profiles Using  
Remote Sensing and Modeling  
579-42-13 W93-70471
- Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501
- MICROWAVE LANDING SYSTEMS**
- Science Sensing (Remote)  
582-03-00 W93-70111
- Global Assessment of Active Volcanism  
428-81-96 W93-70270
- Global Assessment of Active Volcanism  
429-81-96 W93-70287
- MICROWAVE RADIOMETERS**
- Space Data Systems  
586-03-00 W93-70136
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321
- Airborne ESTAR  
461-38-01 W93-70327
- TRMM  
461-38-05 W93-70329
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338
- Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341
- Soil Moisture from SAR  
462-62-05 W93-70349
- NDSC Microwave Instrument Support  
464-13-22 W93-70372
- Microwave Temperature Profiler  
464-14-20 W93-70374
- Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468
- MICROWAVE SCATTERING**
- Satellite Radar for Forest Structure  
462-41-61 W93-70343
- MICROWAVE SENSORS**
- Information and Controls Research and Technology  
506-59-00 W93-70089
- NDSC Microwave Instrument Support  
464-13-22 W93-70372
- MICROWAVE SIGNATURES**
- Validations of Passive Microwave Snow Water  
Equivalent Algorithm  
461-13-00 W93-70319
- MICROWAVE SOUNDING**
- Science Sensing (Remote)  
582-03-00 W93-70111
- Science Sensing (Remote)  
582-03-00 W93-70112
- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea  
Interface  
428-81-80 W93-70268
- Experimental Cloud Analysis Techniques  
578-12-01 W93-70424
- Meteorological Parameters Extraction  
578-12-20 W93-70427
- Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452
- MICROWAVE SPECTRA**
- Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338
- MICROWAVES**
- Propulsion Research and Technology  
506-42-00 W93-70070
- Information and Controls Research and Technology  
506-59-00 W93-70091
- Laboratory Astrophysics  
188-44-57 W93-70201
- Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321
- Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

# MIDDLE ATMOSPHERE

ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

## MIDDLE ATMOSPHERE

Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298

## MILLIMETER WAVES

Submillimeter Astronomy  
188-44-23 W93-70194  
Wind Measurement Assessment  
460-28-41 W93-70314  
MM and Sub-MM Radiometry  
464-12-06 W93-70369  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

## MIMD (COMPUTERS)

Earth and Space Sciences  
509-20-00 W93-70035

## MINERAL METABOLISM

Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236

## MINERALOGY

Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217  
Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409

## MINERALS

Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416

## MINIATURIZATION

Observatory Systems  
582-04-00 W93-70115  
Micro Weather Stations for Mars  
157-04-80 W93-70174

## MIRRORS

Astrometric Imaging Telescope  
157-03-70 W93-70171  
Optical Technology for Space Astronomy  
188-41-23 W93-70186  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210  
AVIRIS Operations  
463-75-63 W93-70364

## MISSION PLANNING

Hypersonic Research and Technology  
505-70-00 W93-70020  
Propulsion Research and Technology  
506-42-00 W93-70068  
Propulsion Research and Technology  
506-42-00 W93-70070  
Systems Analysis  
506-49-00 W93-70082  
Systems Analysis  
506-49-00 W93-70085  
Surface Systems  
583-02-00 W93-70117  
Mars Data Analysis  
155-20-00 W93-70164  
Planetary Data System  
155-20-00 W93-70165  
Mars 94 Gravity  
155-20-03 W93-70167  
Planetary Instrument Development Program/Planetary  
Astronomy High Temperature Superconductor  
Bolometers  
157-05-50 W93-70175  
Optical Stellar Interferometry  
188-41-21 W93-70184  
Astrotech 21  
188-78-44 W93-70215  
Radiation Health  
199-04-11 W93-70226  
Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253  
Ocean Color Data System  
428-82-06 W93-70272

Interdisciplinary ATD Studies  
433-04-00 W93-70295  
Airborne Science Management Operating Working  
Group Support  
462-79-00 W93-70354

AVIRIS Operations  
463-75-63 W93-70364  
Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373

AVIRIS Operations  
465-65-01 W93-70417  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Data Analysis  
578-10-00 W93-70421  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Modeling  
578-40-00 W93-70441  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534

## MIXING CIRCUITS

Science Sensing (Remote)  
582-03-00 W93-70112  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

## MOBILE COMMUNICATION SYSTEMS

Space Communications Research and Technology  
506-72-00 W93-70099

## MODELS

4D Data Assimilation for EOS  
429-81-04 W93-70275  
Forest/Climate Interactions  
462-21-00 W93-70337  
Hydrospheric Processes Program Support for Modeling  
and Data Analysis  
578-97-12 W93-70446

## MODEMS

Space Communications Research and Technology  
506-72-00 W93-70099  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408

## MODULATION

Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523  
Communications and Telemetry  
310-20-37 W93-70535  
Network Signal Processing  
310-30-70 W93-70543  
Communication Systems Research  
310-30-71 W93-70544

## MODULES

Space Flight Research and Technology  
506-48-00 W93-70078

## MOISTURE CONTENT

Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Desert Mesoscale/PBL  
461-13-02 W93-70322  
Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346  
Visiting Scientists  
462-76-49 W93-70353  
Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423  
Geographical Information System for Fusion and  
Analysis of High-Resolution Remote Sensing and Ground  
Truth Data  
656-65-22 W93-70493

## MOJAVE DESERT (CA)

Active Deformation in the Mojave Desert and Walker  
Lane: A Global Positioning System Experiment  
465-13-06 W93-70392

## MOLECULAR BEAM EPITAXY

Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188

## MOLECULAR BIOLOGY

Space Radiation  
199-04-14 W93-70228  
Cell and Development Biology  
199-40-21 W93-70239

## MOLECULAR CLOUDS

Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191

Submillimeter Astronomy  
188-44-23 W93-70194  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Laboratory Astrophysics  
188-44-57 W93-70201  
Properties of Interstellar PAH's  
188-44-57 W93-70202  
Center for Star Formation Studies  
399-20-01 W93-70260

## MOLECULAR GASES

Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156  
Submillimeter Astronomy  
188-44-23 W93-70194  
Measurement of Volcanic Gases  
465-44-05 W93-70414

## MOLECULAR INTERACTIONS

Chemical Kinetics and Spectroscopy of Planetary  
Molecules and Radicals  
154-75-80 W93-70159  
Laboratory Astrophysics  
188-44-57 W93-70201

## MOLECULAR IONS

Propulsion Research and Technology  
506-42-00 W93-70070

## MOLECULAR SPECTRA

Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
154-50-80 W93-70156  
Laser Laboratory Spectroscopy  
464-23-09 W93-70382  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

## MOLECULES

Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals  
188-41-57 W93-70190  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
Laboratory Astrophysics  
188-44-57 W93-70203  
Prebiotic Evolution  
199-52-22 W93-70247  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
Origins of Solar Systems  
452-23-94 W93-70305  
Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380  
Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381

## MOLYBDENUM

Materials and Structures Research and Technology  
506-43-00 W93-70076

## MOMENTS OF INERTIA

Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

## MOMENTUM

ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502

## MOMENTUM TRANSFER

Convective Transport in the Solar Nebula  
452-22-91 W93-70303  
Altimeter Measurements of Wind Speed and Sea Level  
Height With Applications to Air-Sea Interaction Studies:  
Physical Principles and Advanced Techniques  
461-33-02 W93-70325

## MONITORS

Information and Controls Research and Technology  
506-59-00 W93-70090

In-Space Technology Experiments  
506-74-00 W93-70106  
Foreign Visitor Support  
429-97-04 W93-70290

DSN Data Processing and Productivity  
310-40-73 W93-70551

## MONOTECTIC ALLOYS

Metals and Alloys  
674-25-08 W93-70514

## MONTE CARLO METHOD

Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Retracking of Topex Waveform Data  
461-34-01 W93-70326

**MOON**

- Planetology  
151-01-70 W93-70139
- Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141
- Planetary Materials: Experimental Petrology  
152-12-40 W93-70142
- Planetary Materials: Chemistry  
152-13-40 W93-70144
- Planetary Materials: Collection, Preservation and Distribution  
152-20-40 W93-70149
- Telepresence for Planetary Exploration  
186-06-01 W93-70182
- Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217

**MORPHOLOGY**

- Materials and Structures Research and Technology  
506-43-00 W93-70073
- Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- Global Assessment of Active Volcanism  
429-81-97 W93-70288
- Optical Scattering of Plant Canopies  
462-61-00 W93-70346
- Electronic Materials  
674-21-08 W93-70506
- Sounding Rocket Experiments  
879-11-38 W93-70522

**MOsaICS**

- ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439

**MOTION**

- Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438

**MOTION SIMULATORS**

- Flight Systems Research and Technology  
505-68-00 W93-70013

**MOUNTAINS**

- Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395

**MULTI-ANODE MICROCHANNEL ARRAYS**

- Development of UV Photon Counting Geometrically Stable Array Detector - Multi-Anode Microchannel Array (MAMA)  
188-41-24 W93-70187

**MULTIPATH TRANSMISSION**

- Short-Period Tropospheric Noise in Continuous GPS Measurements  
465-27-02 W93-70402

**MULTIPLEXING**

- Solar System Exploration  
199-52-52 W93-70249

**MULTIPLIERS**

- Science Sensing (Remote)  
582-03-00 W93-70112

**MULTIPROCESSING (COMPUTERS)**

- Information and Communications  
586-03-00 W93-70135

**MULTISENSOR APPLICATIONS**

- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375

**MULTISPECTRAL BAND SCANNERS**

- Thermal Infrared Science Support  
462-75-74 W93-70352

**MULTISPECTRAL PHOTOGRAPHY**

- Imaging Spectropolarimeter  
157-03-70 W93-70170

- Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411

**MULTIVARIATE STATISTICAL ANALYSIS**

- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333

**MUSCLES**

- Musculoskeletal  
199-26-14 W93-70238

- Structural Biosystems  
199-40-42 W93-70242

**MUSCULOSKELETAL SYSTEM**

- Clinical Medicine Technology Watch  
199-02-31 W93-70223

- Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- Structural Biosystems  
199-40-42 W93-70242

**MUTATIONS**

- Space Radiation  
199-04-14 W93-70228

**N****N-TYPE SEMICONDUCTORS**

- Surface Systems  
583-02-00 W93-70117

**NACELLES**

- Emissions and Source Noise  
537-02-00 W93-70053

**NAP-OF-THE-EARTH NAVIGATION**

- Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010

**NARROWBAND**

- Ground-Based Infrared Astronomy  
196-41-50 W93-70218

**NASA PROGRAMS**

- Interdisciplinary Technology  
505-90-00 W93-70024

- Interdisciplinary Technology  
505-90-00 W93-70026

- Interdisciplinary Technology  
505-90-00 W93-70027

- Earth and Space Sciences  
509-20-00 W93-70035

- Space Energy Conversion Research and Technology  
506-41-00 W93-70064

- Materials and Structures Research and Technology  
506-43-00 W93-70075

- Systems Analysis  
506-49-00 W93-70085

- Space Communications Research and Technology  
506-72-00 W93-70096

- Space Communications Research and Technology  
506-72-00 W93-70098

- Planetary Materials: General Operations and Laboratory Facilities  
152-30-40 W93-70150

- UV Astronomy and Data Systems  
188-41-51 W93-70189

- Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317

- Airborne Science Management Operating Working Group Support  
462-79-00 W93-70354

- Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418

- Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis  
578-10-00 W93-70421

- Bibliography for Land Processes Publications  
579-82-00 W93-70473

- Landsat Land Cover Pathfinder  
579-98-00 W93-70476

- Information Systems Newsletter  
656-50-65 W93-70477

- PDS: Data Distribution and Archive Technology  
656-61-06 W93-70481

- Data Management Initiative - National Space Science Data Center  
656-61-21 W93-70487

**NASA SPACE PROGRAMS**

- Information and Controls Research and Technology  
506-59-00 W93-70089

- Space Transportation  
584-04-00 W93-70122

- Earth-Orbiting Platforms  
585-03-00 W93-70125

- Earth-Orbiting Platforms  
585-03-00 W93-70126

- Automation and Robotics  
586-02-00 W93-70127

- Volatiles in the Solar System  
196-41-67 W93-70221

- Space Physics Data System  
656-61-18 W93-70485

**NASCOM NETWORK**

- Networks Communication Technology  
310-20-38 W93-70536

**NATIONAL AEROSPACE PLANE PROGRAM**

- Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012

- Computational Aerosciences  
509-10-00 W93-70028

**NATURAL SATELLITES**

- Solar System Studies  
151-01-60 W93-70138
- Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157
- Volatiles in the Solar System  
196-41-67 W93-70221

**NAVIER-STOKES EQUATION**

- Aerothermodynamics Research and Technology  
506-40-00 W93-70062
- Convective Transport in the Solar Nebula  
452-22-91 W93-70303

**NAVIGATION**

- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151
- Telepresence for Planetary Exploration  
186-06-01 W93-70182
- Automated Geophysical Processor Development for the Alaska SAR Facility  
428-82-11 W93-70273
- Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480
- Advanced Transmitter Systems Development  
310-20-64 W93-70538

**NAVIGATION SATELLITES**

- GPS-Based DSN Calibration System  
310-10-61 W93-70530

**NAVIGATORS**

- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151

**NEAR INFRARED RADIATION**

- Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190
- Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar  
188-44-24 W93-70197
- IR Solar Absorption Spectra  
464-12-05 W93-70368

**NEBULAE**

- UV Astronomy and Data Systems  
188-41-51 W93-70189
- Two-Phase Nebulae  
452-22-93 W93-70304

**NEGATIVE FEEDBACK**

- Integrative Biology  
199-40-32 W93-70241

**NEODYMIUM LASERS**

- Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172
- NDSC Differential Absorption Lidar  
464-13-15 W93-70371

**NEON**

- Space Flight Research and Technology  
506-48-00 W93-70080

**NEPTUNE (PLANET)**

- Neptune Data Analysis  
889-59-00 W93-70524
- Neptune Data Analysis  
889-59-00 W93-70525
- Neptune Data Analysis Program  
889-59-00 W93-70526

**NEPTUNE ATMOSPHERE**

- Neptune Data Analysis  
889-59-00 W93-70524
- Neptune Data Analysis  
889-59-00 W93-70525

**NEPTUNE SATELLITES**

- Neptune Data Analysis  
889-59-00 W93-70525

**NERVOUS SYSTEM**

- Cardiopulmonary Physiology  
199-14-12 W93-70233

**NETWORKS**

- Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
465-13-06 W93-70392

**NEURAL NETS**

- Information and Controls Research and Technology  
506-59-00 W93-70088
- Information and Controls Research and Technology  
506-59-00 W93-70090
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495
- Mission Operations Technology  
310-40-45 W93-70546

**NEUROLOGY**

- Neuroscience (Biomedical)  
199-16-12 W93-70234



**NEUTRAL ATMOSPHERES**

Thermosphere-Ionosphere-Mesosphere-Magnetospheric Interactions  
432-48-00 W93-70294

**NEUTRAL ATOMS**

Materials and Structures Research and Technology  
506-43-00 W93-70077  
Properties of Interstellar PAH's  
188-44-57 W93-70202

**NEUTRAL GASES**

Sounding Rockets: Space Plasma Physics Experiments  
435-11-00 W93-70298

**NEUTRON ACTIVATION ANALYSIS**

Planetary Materials: Chemistry  
152-13-40 W93-70144

**NEUTRON SPECTROMETERS**

Planetary Instrument Definition and Development  
157-03-50 W93-70169

**NEUTRONS**

Materials and Structures Research and Technology  
506-43-00 W93-70076

**NEW ZEALAND**

Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416

**NIGER**

Land Surface Climatology: HAPEX  
462-32-00 W93-70340

**NIMBUS SATELLITES**

Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426

**NIMBUS 4 SATELLITE**

Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429

**NIMBUS 7 SATELLITE**

EOS IDS, EOSDIS Money  
428-81-36 W93-70266  
Studies of Volcanic SO<sub>2</sub>  
428-81-99 W93-70271  
EOS IDS, Stratospheric Temperature and Trace Gas Trends  
429-81-36 W93-70280  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289

**NITRIC ACID**

Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450

**NITRIC OXIDE**

Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361

**NITROGEN**

In-Space Technology Experiments  
506-74-00 W93-70107  
Characteristics of Volatiles in Interplanetary Dust Particles  
199-52-11 W93-70245  
Biogeochemical Cycling Research on the Oregon Transect  
462-43-00 W93-70344  
Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345  
Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454

**NITROGEN OXIDES**

Emissions and Source Noise  
537-02-00 W93-70053  
Emissions and Source Noise  
537-02-00 W93-70054  
Laser Diode Sensor  
464-11-07 W93-70366

**NITROUS OXIDES**

Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384

**NOAA SATELLITES**

Studies of Volcanic SO<sub>2</sub>  
428-81-99 W93-70271  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289

**NOISE GENERATORS**

Emissions and Source Noise  
537-02-00 W93-70055

**NOISE INTENSITY**

Emissions and Source Noise  
537-02-00 W93-70053  
Emissions and Source Noise  
537-02-00 W93-70054  
Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and J SSM/I Data  
665-35-09 W93-70501

**NOISE MEASUREMENT**

Emissions and Source Noise  
537-02-00 W93-70053  
Short-Period Tropospheric Noise in Continuous GPS Measurements  
465-27-02 W93-70402

**NOISE POLLUTION**

Advanced Turboprop Systems  
535-03-00 W93-70045  
Atmospheric Effects  
537-01-00 W93-70049  
Emissions and Source Noise  
537-02-00 W93-70055  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Community Noise and Sonic Boom  
537-03-00 W93-70057

**NOISE PREDICTION**

Advanced Rotorcraft Technology  
532-06-00 W93-70040  
Advanced Turboprop Systems  
535-03-00 W93-70044  
Emissions and Source Noise  
537-02-00 W93-70053  
Emissions and Source Noise  
537-02-00 W93-70055  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Community Noise and Sonic Boom  
537-03-00 W93-70057

**NOISE REDUCTION**

Advanced Rotorcraft Technology  
532-06-00 W93-70039  
Advanced Rotorcraft Technology  
532-06-00 W93-70040  
High-Performance Flight Research  
533-02-00 W93-70043  
Advanced Turboprop Systems  
535-03-00 W93-70044  
Atmospheric Effects  
537-01-00 W93-70051  
Emissions and Source Noise  
537-02-00 W93-70053  
Emissions and Source Noise  
537-02-00 W93-70054  
Emissions and Source Noise  
537-02-00 W93-70055  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405  
Astrometric Development Technology  
310-10-60 W93-70529  
Advanced Space Systems for Users of NASA Networks  
310-20-46 W93-70537  
Radio Systems Development  
310-20-66 W93-70540

**NOISE SPECTRA**

Short-Period Tropospheric Noise in Continuous GPS Measurements  
465-27-02 W93-70402

**NONDESTRUCTIVE TESTS**

Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
Aging Aircraft  
538-02-00 W93-70061  
Materials and Structures Research and Technology  
506-43-00 W93-70073  
Automation and Robotics  
586-02-00 W93-70129  
Automation and Robotics  
586-02-00 W93-70130

**NONEQUILIBRIUM FLOW**

Hypersonics Research and Technology  
506-73-00 W93-70100

**NONEQUILIBRIUM RADIATION**

Aerothermodynamics Research and Technology  
506-40-00 W93-70062

**NONLINEAR SYSTEMS**

Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292

**NONLINEARITY**

Altitude Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325

**NORTH AMERICA**

Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
North American Fiducial Network  
465-14-11 W93-70397

**NOZZLES**

Emissions and Source Noise  
537-02-00 W93-70054

**NUCLEAR ASTROPHYSICS**

Observatory Systems  
582-04-00 W93-70115  
Integral Mission Definition Study  
188-78-01 W93-70211

**NUCLEAR FUELS**

Space Transportation  
584-04-00 W93-70123

**NUCLEAR PROPULSION**

System Analysis  
506-49-00 W93-70083  
Space Transportation  
584-04-00 W93-70122  
Space Transportation  
584-04-00 W93-70123

**NUCLEATION**

Microgravity Nucleation and Particle Coagulation Experiments  
152-20-01 W93-70148  
Laboratory Astrophysics  
188-44-57 W93-70203  
Metals and Alloys  
674-25-08 W93-70514  
Glasses and Ceramics  
674-26-08 W93-70516

**NUCLEI (NUCLEAR PHYSICS)**

Cosmic and Heliospheric Physics  
170-10-10 W93-70176

**NUCLEIC ACIDS**

Space Radiation  
199-04-14 W93-70228

**NUCLIDES**

Planetary Materials: Geochronology  
152-14-40 W93-70146  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147

**NUMERICAL ANALYSIS**

Dynamics of Planetary Atmospheres  
154-20-80 W93-70153  
Theory of Geodetic Transformations  
465-15-06 W93-70398  
Meteorological Parameters Extraction  
578-12-20 W93-70427  
Global Climate Modeling  
578-41-01 W93-70442

**NUMERICAL WEATHER FORECASTING**

Meteorological Parameters Extraction  
578-12-20 W93-70427

**NUSTATION**

Earth Rotation and Mantle Structure  
579-36-03 W93-70460  
Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

**NUTRIENTS**

Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472

**NUTRITION**

Musculoskeletal (Biomedical)  
199-26-12 W93-70237

O

**OBSERVATORIES**

Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195  
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar  
188-44-24 W93-70197

**GAMMA RAY ASTRONOMY**

Gamma Ray Astronomy  
188-46-57 W93-70207  
Astrotech 21  
188-78-44 W93-70215  
Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements  
464-23-08 W93-70381

Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
465-13-06 W93-70392

**GPS/VLBI VERTICAL MEASUREMENT**

465-14-09 W93-70396

**OCEAN BOTTOM**

Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457

**OCEAN COLOR SCANNER**

Ocean Color Data System  
428-82-06 W93-70272  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355

**OCEAN CURRENTS**

Role of Air-Sea Exchanges and Ocean Circulation (Computing) W93-70263  
 428-81-10 W93-70263  
 Role of Air-Sea Exchanges and Ocean Circulation (Science) W93-70277  
 429-81-10 W93-70277  
 Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques W93-70325  
 461-33-02 W93-70325  
 Airborne ESTAR W93-70327  
 461-38-01 W93-70327  
 Oceanic Remote Sensing Library W93-70335  
 461-66-16 W93-70335  
 Tropical Ocean Circulation from Altimetry and Numerical Modeling W93-70430  
 578-21-12 W93-70430  
 Ocean Circulation from Satellite Altimetry W93-70431  
 578-22-24 W93-70431  
 Studies of Sea Surface Temperature and Topography W93-70432  
 578-22-25 W93-70432  
 Large Scale Air-Sea Interactions W93-70433  
 578-22-26 W93-70433  
 Climate Stability: The Role of the Hydrological Cycle and the Thermohaline Circulation W93-70436  
 578-31-14 W93-70436  
 An Ocean General Circulation Model for Climate Studies W93-70443  
 578-41-43 W93-70443

**OCEAN DATA ACQUISITIONS SYSTEMS**  
 Airborne Oceanographic Lidar (AOL) W93-70358  
 463-11-79 W93-70358

**OCEAN DYNAMICS**  
 Oceanic Remote Sensing Library W93-70335  
 461-66-16 W93-70335  
 Phytoplankton Dynamics of North Pacific Ocean W93-70356  
 463-11-09 W93-70356  
 Remote Sensing of Air-Sea Fluxes W93-70426  
 578-12-19 W93-70426  
 JPL Oceanography Group Common Computer System W93-70434  
 578-22-27 W93-70434

**OCEAN MODELS**  
 Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques W93-70325  
 461-33-02 W93-70325  
 Polarimetric Data Analysis W93-70334  
 461-64-11 W93-70334  
 Remote Sensing of Air-Sea Fluxes W93-70426  
 578-12-19 W93-70426  
 Tropical Ocean Circulation from Altimetry and Numerical Modeling W93-70430  
 578-21-12 W93-70430  
 Ocean Circulation from Satellite Altimetry W93-70431  
 578-22-24 W93-70431  
 Large Scale Air-Sea Interactions W93-70433  
 578-22-26 W93-70433  
 JPL Oceanography Group Common Computer System W93-70434  
 578-22-27 W93-70434  
 Climate Stability: The Role of the Hydrological Cycle and the Thermohaline Circulation W93-70436  
 578-31-14 W93-70436  
 An Ocean General Circulation Model for Climate Studies W93-70443  
 578-41-43 W93-70443

**OCEAN SURFACE**  
 Role of Air-Sea Exchanges and Ocean Circulation (Computing) W93-70263  
 428-81-10 W93-70263  
 Automated Geophysical Processor Development for the Alaska SAR Facility W93-70273  
 428-82-11 W93-70273  
 Polar Exchange at the Sea Surface: JPL Component W93-70282  
 429-81-64 W93-70282  
 IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface W93-70284  
 429-81-80 W93-70284  
 IR Remote Sensing of SST W93-70310  
 460-21-28 W93-70310  
 Atmospheric Backscatter Experiment W93-70313  
 460-22-53 W93-70313  
 Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques W93-70325  
 461-33-02 W93-70325  
 Retracking of Topex Waveform Data W93-70326  
 461-34-01 W93-70326  
 Meteorological Parameters Extraction W93-70427  
 578-12-20 W93-70427  
 Tropical Ocean Circulation from Altimetry and Numerical Modeling W93-70430  
 578-21-12 W93-70430  
 Global Monthly Mean Ocean Variability W93-70435  
 578-22-29 W93-70435

**OCEANOGRAPHIC PARAMETERS**

Airborne ESTAR W93-70327  
 461-38-01 W93-70327  
 Global Monthly Mean Ocean Variability W93-70435  
 578-22-29 W93-70435  
 Radar-Altimeter Ice Data System W93-70448  
 578-97-20 W93-70448

**OCEANOGRAPHY**  
 EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface W93-70268  
 428-81-80 W93-70268  
 Oceanic Remote Sensing Library W93-70335  
 461-66-16 W93-70335  
 Phytoplankton Dynamics of North Pacific Ocean W93-70356  
 463-11-09 W93-70356  
 Bio-Optical Interpretation of Ocean Color Imagery W93-70357  
 463-11-62 W93-70357  
 Airborne Oceanographic Lidar (AOL) W93-70358  
 463-11-79 W93-70358  
 JPL Oceanography Group Common Computer System W93-70434  
 578-22-27 W93-70434  
 DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases W93-70492  
 656-65-21 W93-70492  
 Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and SSM/I Data W93-70501  
 665-35-09 W93-70501

**OCEANS**  
 Role of Air-Sea Exchanges and Ocean Circulation (Computing) W93-70263  
 428-81-10 W93-70263  
 Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project W93-70274  
 428-82-18 W93-70274  
 Radiative Effects in Clouds First International Satellite Cloud Climatology Regional Experiment W93-70315  
 460-42-00 W93-70315  
 Scatterometer Research W93-70323  
 461-31-09 W93-70323  
 Airborne Precipitation Radar W93-70332  
 461-51-16 W93-70332  
 ARISTOTELES GPS Receiver Development W93-70406  
 465-35-05 W93-70406  
 Meteorological Parameters Extraction W93-70427  
 578-12-20 W93-70427  
 Ocean Circulation from Satellite Altimetry W93-70431  
 578-22-24 W93-70431  
 An Ocean General Circulation Model for Climate Studies W93-70443  
 578-41-43 W93-70443

**ON-LINE SYSTEMS**  
 NASA/IPAC Extragalactic Database W93-70259  
 399-20-00 W93-70259  
 Crustal Dynamics Data Information System (CDDIS) W93-70459  
 579-32-06 W93-70459  
 LTP Computer Support W93-70465  
 579-41-04 W93-70465  
 NSSDC Astrophysics Data Systems Support W93-70484  
 656-61-17 W93-70484

**ONBOARD DATA PROCESSING**  
 Information and Communications W93-70134  
 586-02-00 W93-70134  
 Advanced Space Systems for Users of NASA Networks W93-70537  
 310-20-46 W93-70537

**OORT CLOUD**  
 Origins of Solar Systems W93-70305  
 452-23-94 W93-70305

**OPACITY**  
 Planetary Atmospheric Composition, Structure, and History W93-70152  
 154-10-80 W93-70152  
 Dynamics of Planetary Atmospheres W93-70153  
 154-20-80 W93-70153  
 Mars Atmosphere Dust Opacity W93-70163  
 155-04-00 W93-70163

**OPERATING COSTS**  
 Advanced High Temperature Engine Materials W93-70036  
 510-01-00 W93-70036  
 Atmospheric Effects W93-70049  
 537-01-00 W93-70049  
 Planetary Materials: General Operations and Laboratory Facilities W93-70150  
 152-30-40 W93-70150

**OPERATING SYSTEMS (COMPUTERS)**  
 Information and Communications W93-70137  
 586-03-00 W93-70137

**OPERATING TEMPERATURE**  
 Observatory Systems W93-70114  
 582-04-00 W93-70114

**OPERATIONAL PROBLEMS**  
 Ground-Based Support of Solar Physics W93-70179  
 170-38-52 W93-70179

**OPERATIONS RESEARCH**

Information and Controls Research and Technology W93-70087  
 506-59-00 W93-70087  
 Planning and Scheduling Systems Technology W93-70534  
 310-20-36 W93-70534

**OPERATOR PERFORMANCE**  
 Expert Systems for Automation of Operations W93-70547  
 310-40-47 W93-70547

**OPERATORS (PERSONNEL)**  
 Expert Systems for Automation of Operations W93-70547  
 310-40-47 W93-70547

**OPTICAL COMMUNICATION**  
 Materials and Structures Research and Technology W93-70075  
 506-43-00 W93-70075  
 Optical Communications Technology Development W93-70541  
 310-20-67 W93-70541

**OPTICAL COMPUTERS**  
 Information and Communications W93-70135  
 586-03-00 W93-70135

**OPTICAL DATA PROCESSING**  
 Information and Communications W93-70135  
 586-03-00 W93-70135  
 Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions W93-70255  
 370-03-00 W93-70255  
 Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis W93-70495  
 656-65-25 W93-70495  
 Space Systems and Navigation Technology W93-70532  
 310-10-63 W93-70532

**OPTICAL DISKS**  
 Information and Communications W93-70135  
 586-03-00 W93-70135  
 Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions W93-70255  
 370-03-00 W93-70255

**OPTICAL FILTERS**  
 Imaging Spectropolarimeter W93-70170  
 157-03-70 W93-70170

**OPTICAL HETERODYNING**  
 Advanced Infrared Astronomy W93-70220  
 196-41-54 W93-70220

**OPTICAL MATERIALS**  
 Optical Technology for Space Astronomy W93-70186  
 188-41-23 W93-70186

**OPTICAL MEASUREMENT**  
 Land Surface Climatology: HAPEX W93-70340  
 462-32-00 W93-70340

**OPTICAL MEASURING INSTRUMENTS**  
 Astrotech 21 W93-70215  
 188-78-44 W93-70215

**OPTICAL MEMORY (DATA STORAGE)**  
 PDS: Data Distribution and Archive Technology W93-70481  
 656-61-06 W93-70481  
 Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives W93-70490  
 656-65-06 W93-70490

**OPTICAL PROPERTIES**  
 Optical Scattering of Plant Canopies W93-70346  
 462-61-00 W93-70346

**OPTICAL RADAR**  
 Science Sensing (Remote) W93-70110  
 582-03-00 W93-70110  
 Science Sensing (Remote) W93-70113  
 582-03-00 W93-70113  
 Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies) W93-70173  
 157-03-90 W93-70173  
 CO2 Lidar Backscatter Experiment W93-70309  
 460-21-00 W93-70309  
 Airborne Doppler Lidar W93-70311  
 460-21-52 W93-70311  
 Lidar Target Calibration Facility W93-70312  
 460-22-52 W93-70312  
 Atmospheric Backscatter Experiment W93-70313  
 460-22-53 W93-70313  
 Wind Measurement Assessment W93-70314  
 460-28-41 W93-70314  
 Airborne Oceanographic Lidar (AOL) W93-70358  
 463-11-79 W93-70358  
 NDSC Differential Absorption Lidar W93-70371  
 464-13-15 W93-70371  
 NDSC Microwave Instrument Support W93-70372  
 464-13-22 W93-70372  
 Satellite Observations of Volcanic Aerosols W93-70410  
 465-44-00 W93-70410

**OPTIMIZATION**  
 Computational/Aeroscience W93-70031  
 509-10-00 W93-70031  
 Materials and Structures Research and Technology W93-70074  
 506-43-00 W93-70074

**ORBIT CALCULATION**  
 In-Space Technology Experiments W93-70107  
 506-74-00 W93-70107  
 Flight Dynamics Technology W93-70528  
 310-10-26 W93-70528

## ORBIT INSERTION

Space Systems and Navigation Technology  
310-10-63 W93-70532

**ORBIT INSERTION**  
Space Transportation  
584-04-00 W93-70123

**ORBIT PERTURBATION**  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460

**ORBIT TRANSFER VEHICLES**  
Propulsion Research and Technology  
506-42-00 W93-70068

**ORBITAL POSITION ESTIMATION**  
Flight Dynamics Technology  
310-10-26 W93-70528

**ORBITAL SERVICING**  
Information and Controls Research and Technology  
506-59-00 W93-70092

**ORDER-DISORDER TRANSFORMATIONS**  
Glasses and Ceramics  
674-26-05 W93-70515

**OREGON**  
Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416

**ORGANIC CHEMISTRY**  
Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246

**ORGANIC COMPOUNDS**  
Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246

**ORGANIC MATERIALS**  
Advanced Composite Materials Technology  
510-02-00 W93-70038  
Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358

**ORGANISMS**  
Cell and Development Biology  
199-40-21 W93-70239  
Structural Biosystems  
199-40-42 W93-70242  
Prebiotic Evolution  
199-52-22 W93-70247  
The Early Evolution of Life  
199-52-32 W93-70248  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252

**ORGANIZATIONS**  
DSN Data Processing and Productivity  
310-40-73 W93-70551

**ORGANS**  
Integrative Biology  
199-40-32 W93-70241

**ORTHOSTATIC TOLERANCE**  
Cardiopulmonary Physiology  
199-14-12 W93-70233

**OSCILLATIONS**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179

**OSCILLATOR STRENGTHS**  
Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals  
188-41-57 W93-70190  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191

**OSCILLATORS**  
Science Sensing (Remote)  
582-03-00 W93-70112  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

**OSO**  
High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205

**OSTEOPOROSIS**  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237

**OUTCROPS**  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic  
Resurfacing  
151-02-00 W93-70140

**OXIDATION**  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386

**OXYGEN**  
Materials and Structures Research and Technology  
506-43-00 W93-70077  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143

Submillimeter Astronomy  
188-44-23 W93-70194  
Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245  
Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253

**OXYGEN ATOMS**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Materials and Structures Research and Technology  
506-43-00 W93-70073

**OXYGEN PRODUCTION**  
In-Space Technology Experiments  
506-74-00 W93-70107

**OZONE**  
Atmospheric Effects  
537-01-00 W93-70049  
Atmospheric Effects  
537-01-00 W93-70050  
Atmospheric Effects  
537-01-00 W93-70052  
EOS IDS, EOSDIS Money  
428-81-36 W93-70266  
EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280  
Ozone Measurements  
464-11-05 W93-70365  
Laser Diode Sensor  
464-11-07 W93-70366  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Homogeneous and Heterogeneous Processes of  
Atmospheric Interest  
464-21-05 W93-70377  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
Remote Sensing of Active and Recently Active Volcanic  
Features  
465-44-01 W93-70411  
Two-Dimensional Stratospheric Chemical Model  
Radiation  
579-23-01 W93-70451  
Simulation of Tropospheric Ozone  
579-24-00 W93-70453  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454  
Climatological Stratospheric Modeling  
579-24-09 W93-70455

**OZONE DEPLETION**  
Emissions and Source Noise  
537-02-00 W93-70053  
Emissions and Source Noise  
537-02-00 W93-70054  
Airborne IR Spectrometry  
464-12-00 W93-70367  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
MM and Sub-MM Radiometry  
464-12-06 W93-70369  
Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370  
Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373  
Microwave Temperature Profiler  
464-14-20 W93-70374  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452  
Windows on Global Change  
665-82-03 W93-70503

**OZONOMETRY**  
Ozone Measurements  
464-11-05 W93-70365  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373

**OZONOSPHERE**  
Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373

## P

**P BAND**  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
465-68-01 W93-70420

**P WAVES**  
Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399

**P-TYPE SEMICONDUCTORS**  
Surface Systems  
583-02-00 W93-70117

**PACIFIC OCEAN**  
Atmospheric Backscatter Experiment  
460-22-53 W93-70313  
TRMM  
461-38-05 W93-70329  
Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430

**PACKAGING**  
Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188

**PACKET TRANSMISSION**  
Communications and Telemetry  
310-20-37 W93-70535

**PACKETS (COMMUNICATION)**  
Communications and Telemetry  
310-20-37 W93-70535

**PAIR PRODUCTION**  
Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204

**PALEONTOLOGY**  
Planetology  
151-01-70 W93-70139  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222  
The Early Evolution of Life  
199-52-32 W93-70248  
Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409

**PARABOLIC FLIGHT**  
General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232

**PARALLAX**  
HIPPARCOS VLBI  
399-18-00 W93-70256

**PARALLEL COMPUTERS**  
Computational Aerosciences  
509-10-00 W93-70029  
Earth and Space Sciences  
509-20-00 W93-70035  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Advanced Telemetry Processing Technology  
310-40-51 W93-70550

**PARALLEL PROCESSING (COMPUTERS)**  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Computational Aerosciences  
509-10-00 W93-70028  
Computational Aerosciences  
509-10-00 W93-70029  
Computational Aerosciences  
509-10-00 W93-70030  
Computational/Aeroscience  
509-10-00 W93-70031  
Earth and Space Sciences  
509-20-00 W93-70033  
Earth and Space Sciences  
509-20-00 W93-70034  
Earth and Space Sciences  
509-20-00 W93-70035  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495

- PARALLEL PROGRAMMING**  
Earth and Space Sciences  
509-20-00 W93-70035
- PARAMETERIZATION**  
Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Subgrid Variation of Surface Parameters  
578-42-15 W93-70444  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457  
Neptune Data Analysis  
889-59-00 W93-70525
- PARTIAL DIFFERENTIAL EQUATIONS**  
Earth and Space Sciences  
509-20-00 W93-70035
- PARTICLE ACCELERATION**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180
- PARTICLE ACCELERATORS**  
Propulsion Research and Technology  
506-42-00 W93-70070
- PARTICLE COLLISIONS**  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180
- PARTICLE INTERACTIONS**  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178  
Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225
- PARTICLE SIZE DISTRIBUTION**  
Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148  
Two-Phase Nebulae  
452-22-93 W93-70304
- PARTICULATES**  
Automation and Robotics  
586-02-00 W93-70133  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362  
Remote Sensing of Active and Recently Active Volcanic  
Features  
465-44-01 W93-70411  
Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450  
Fluid Physics  
674-24-08 W93-70512
- PATHOGENESIS**  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- PATHOLOGICAL EFFECTS**  
Environmental Health  
199-04-11 W93-70227
- PATHOLOGY**  
Environmental Health  
199-04-11 W93-70227
- PATTERN RECOGNITION**  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488
- PAYLOAD CONTROL**  
Mission Operations Technology  
310-40-45 W93-70546
- PAYLOAD INTEGRATION**  
Space Flight Research and Technology  
506-48-00 W93-70080
- PAYLOADS**  
In-Space Experiments  
506-74-00 W93-70105  
Space Transportation  
584-04-00 W93-70123  
Information and Communications  
586-03-00 W93-70135  
Optical Technology for Space Astronomy  
188-41-23 W93-70186  
Exploration Exobiology  
199-52-82 W93-70251
- Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298  
Sounding Rocket Experiments  
879-11-38 W93-70522
- PEAT**  
Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360
- PENINSULAS**  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408  
ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- PERFORMANCE PREDICTION**  
Emissions and Source Noise  
537-02-00 W93-70054  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Astrometric Imaging Telescope  
157-03-70 W93-70171  
Optical Interferometry in Space  
188-78-41 W93-70213  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549
- PERFORMANCE TESTS**  
Space Communications Research and Technology  
506-72-00 W93-70099  
In-Space Experiments  
506-74-00 W93-70105  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Process Studies: Radiation Dynamics and Hydrology,  
Radiation and Dynamic Processes  
460-20-00 W93-70308  
Thermal Infrared Science Support  
462-75-74 W93-70352  
Solar System Visualization (SSV): Scientific Tools for  
NASA/JPL Image Archives  
656-65-06 W93-70490
- PERIODIC VARIATIONS**  
Integrative Biology  
199-40-32 W93-70241
- PERIODICALS**  
Oceanic Remote Sensing Library  
461-66-16 W93-70335
- PERMAFROST**  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
ASF SAR Interferometry  
665-35-01 W93-70500
- PERMITTIVITY**  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Fluid Physics  
674-24-08 W93-70512
- PERSONAL COMPUTERS**  
Musculoskeletal  
199-26-14 W93-70238  
Computer and Information Systems Support  
579-82-90 W93-70474
- PERSONNEL**  
Interdisciplinary Technology  
505-90-00 W93-70027  
Management Support: Origins of Solar Systems  
Research Program  
452-89-91 W93-70307
- PERSONNEL SELECTION**  
Behavior, Performance and Human Factors  
199-06-12 W93-70231
- PERTURBATION**  
Origins of Solar Systems  
452-23-94 W93-70305  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438  
Climatological Stratospheric Modeling  
579-24-09 W93-70455
- PETROGRAPHY**  
Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145
- PETROLOGY**  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials: Chemistry  
152-13-40 W93-70144
- Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145  
Exobiology: Intact Capture Technology Development  
199-52-54 W93-70250  
Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405
- PHARMACOLOGY**  
Neuroscience (Biomedical)  
199-16-12 W93-70234  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237  
Biotechnology  
674-23-08 W93-70509
- PHASE CHANGE MATERIALS**  
Materials and Structures Research and Technology  
506-43-00 W93-70077  
Space Flight Research and Technology  
506-48-00 W93-70078
- PHASE SEPARATION (MATERIALS)**  
Metals and Alloys  
674-25-05 W93-70513
- PHASE TRANSFORMATIONS**  
Fluid Physics  
674-24-05 W93-70511  
Fluid Physics  
674-24-08 W93-70512
- PHASED ARRAYS**  
Space Communications Research and Technology  
506-72-00 W93-70096
- PHENOLOGY**  
Satellite Radar for Forest Structure  
462-41-61 W93-70343  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466  
ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499
- PHOBOS**  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166
- PHONONS**  
Surface Systems  
583-02-00 W93-70117
- PHOSPHORUS**  
Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245
- PHOTOCATHODES**  
Development of UV Photon Counting Geometrically  
Stable Array Detector - Multi-Anode Microchannel Array  
(MAMA)  
188-41-24 W93-70187
- PHOTOCHEMICAL REACTIONS**  
EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea  
Interface  
428-81-80 W93-70268  
IDS Science for WHOI/GSFC Eos Project:  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376  
Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379  
Data Survey and Evaluation  
464-41-04 W93-70385  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386  
Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452  
Simulation of Tropospheric Ozone  
579-24-00 W93-70453  
Climatological Stratospheric Modeling  
579-24-09 W93-70455  
Windows on Global Change  
665-82-03 W93-70503
- PHOTOCONDUCTORS**  
Science Sensing (Remote)  
582-03-00 W93-70109
- PHOTODIODES**  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172  
Mars Lidar (Lidar from the Mars Surface and Mars Orbit  
for Atmospheric Studies)  
157-03-90 W93-70173
- PHOTODISSOCIATION**  
Chemical Kinetics and Spectroscopy of Planetary  
Molecules and Radicals  
154-75-80 W93-70159

## PHOTOELECTRIC EMISSION

- Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190
- PHOTOELECTRIC EMISSION**  
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190
- PHOTOELECTRONS**  
Development of UV Photon Counting Geometrically Stable Array Detector - Multi-Anode Microchannel Array (MAMA)  
188-41-24 W93-70187
- PHOTO GEOLOGY**  
Planetary  
151-01-70 W93-70139
- PHOTOGRAPHS**  
Planetary Hardcopy Preservation Task  
656-61-20 W93-70486
- PHOTOINTERPRETATION**  
Evolution of Volcanic Terrains  
465-44-02 W93-70412
- PHOTOLYSIS**  
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386
- PHOTOMAPPING**  
Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411
- PHOTOMETERS**  
Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195
- PHOTOMETRY**  
U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166  
Infrared Studies of Planetary Debris Around Young Main Sequence Stars  
452-11-93 W93-70301  
Neptune Data Analysis Program  
889-59-00 W93-70526
- PHOTOMICROGRAPHY**  
Chemical Evolution of Interstellar Ices: The Connection with Primitive Solar System Materials  
452-33-93 W93-70306
- PHOTONICS**  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70091
- PHOTONS**  
Development of UV Photon Counting Geometrically Stable Array Detector - Multi-Anode Microchannel Array (MAMA)  
188-41-24 W93-70187  
Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)  
188-46-01 W93-70204  
Gamma Ray Astronomy  
188-46-57 W93-70207  
X-Ray Astronomy CCD  
188-46-59 W93-70209
- PHOTOSPHERE**  
Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180
- PHOTOSYNTHESIS**  
Forest/Climate Interactions  
462-21-00 W93-70337  
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362
- PHOTOVOLTAIC CONVERSION**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Space Energy Conversion Research and Technology  
506-41-00 W93-70065  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067
- PHYSICAL EXAMINATIONS**  
Longitudinal Studies (Medical Operations Longitudinal Studies)  
199-02-31 W93-70224
- PHYSICAL EXERCISE**  
Clinical Medicine Technology Watch  
199-02-31 W93-70223

- Cardiopulmonary Physiology  
199-14-12 W93-70233  
Regulatory Physiology (Biomedical)  
199-18-12 W93-70235  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- PHYSICAL OPTICS**  
Materials and Structures Research and Technology  
506-43-00 W93-70075
- PHYSIOCHEMISTRY**  
Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253
- PHYSIOLOGICAL EFFECTS**  
Longitudinal Studies (Medical Operations Longitudinal Studies)  
199-02-31 W93-70224  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236  
Cell and Developmental Biology  
199-40-22 W93-70240  
Integrative Biology  
199-40-32 W93-70241  
Structural Biosystems  
199-40-42 W93-70242
- PHYSIOLOGICAL FACTORS**  
Longitudinal Studies (Medical Operations Longitudinal Studies)  
199-02-31 W93-70224
- PHYSIOLOGICAL RESPONSES**  
Radiation Health  
199-04-11 W93-70226  
Environmental Health  
199-04-11 W93-70227  
Regulatory Physiology (Biomedical)  
199-18-12 W93-70235  
Cell and Developmental Biology  
199-40-22 W93-70240  
Integrative Biology  
199-40-32 W93-70241  
Structural Biosystems  
199-40-42 W93-70242
- PHYSIOLOGY**  
Regulatory Physiology (Biomedical)  
199-18-12 W93-70235  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346
- PHYTOPLANKTON**  
Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- PIGMENTS**  
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- PINTLES**  
Earth-to-Orbit Transportation  
584-03-00 W93-70121
- PLANAR STRUCTURES**  
Automation and Robotics  
586-02-00 W93-70129
- PLANE WAVES**  
Science Sensing (Remote)  
582-03-00 W93-70112
- PLANETARY ATMOSPHERES**  
Solar System Studies  
151-01-60 W93-70138  
Planetary Atmospheric Composition, Structure, and History  
154-10-80 W93-70152  
Dynamical Properties of Planetary Atmospheres  
154-20-80 W93-70154  
Spectral and Physical Properties of Planetary Atmospheric Constituents  
154-50-80 W93-70156  
Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157  
Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158  
Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals  
154-75-80 W93-70159  
Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160

- Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217  
Advanced Infrared Astronomy  
196-41-54 W93-70220  
Construction of an Advanced Software Tool for Planetary Atmospheric Modeling  
656-65-24 W93-70494  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498
- PLANETARY BOUNDARY LAYER**  
Mars Surface and Atmosphere Studies  
155-04-00 W93-70162  
Micro Weather Stations for Mars  
157-04-80 W93-70174  
Subgrid Variation of Surface Parameters  
578-42-15 W93-70444
- PLANETARY COMPOSITION**  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs  
152-13-60 W93-70145  
Planetary Materials: Geochronology  
152-14-40 W93-70146  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Planetary Materials: Collection, Preservation and Distribution  
152-20-40 W93-70149  
Planetary Materials: General Operations and Laboratory Facilities  
152-30-40 W93-70150
- PLANETARY CRATERS**  
Planetary Materials: Geochronology  
152-14-40 W93-70146
- PLANETARY ENVIRONMENTS**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064
- PLANETARY EVOLUTION**  
Solar System Studies  
151-01-60 W93-70138  
Planetary  
151-01-70 W93-70139  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs  
152-13-60 W93-70145  
Planetary Materials: Geochronology  
152-14-40 W93-70146  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Planetary Atmospheric Composition, Structure, and History  
154-10-80 W93-70152  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222  
Prebiotic Evolution  
199-52-22 W93-70247  
The Early Evolution of Life  
199-52-32 W93-70248  
Center for Star Formation Studies  
399-20-01 W93-70260  
Infrared Studies of Planetary Debris Around Young Main Sequence Stars  
452-11-93 W93-70301  
Two-Phase Nebulae  
452-22-93 W93-70304  
Origins of Solar Systems  
452-23-94 W93-70305  
Management Support: Origins of Solar Systems Research Program  
452-89-91 W93-70307  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460  
Core-Mantle Excitation  
579-36-11 W93-70463
- PLANETARY GEOLOGY**  
Solar System Studies  
151-01-60 W93-70138

- Planetology  
151-01-70 W93-70139  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140  
Planetary Materials: General Operations and Laboratory Facilities  
152-30-40 W93-70150
- PLANETARY IONOSPHERES**  
Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157
- PLANETARY MAGNETIC FIELDS**  
Advanced Magnetometer  
465-31-01 W93-70404
- PLANETARY MAGNETOSPHERES**  
Magnetospheric Coupling  
432-36-00 W93-70293
- PLANETARY MAGNETOTAILS**  
Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292
- PLANETARY MASS**  
Infrared Studies of Planetary Debris Around Young Main Sequence Stars  
452-11-93 W93-70301
- PLANETARY NEBULAE**  
Solar System Studies  
151-01-60 W93-70138  
Planet-Forming Disks  
452-21-93 W93-70302  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303
- PLANETARY RINGS**  
Solar System Studies  
151-01-60 W93-70138  
Planetary Data System  
155-20-00 W93-70165  
Neptune Data Analysis  
889-59-00 W93-70525
- PLANETARY ROTATION**  
Dynamics of Planetary Atmospheres  
154-20-80 W93-70153
- PLANETARY STRUCTURE**  
Solar System Studies  
151-01-60 W93-70138
- PLANETARY SURFACES**  
Solar System Studies  
151-01-60 W93-70138  
Planetology  
151-01-70 W93-70139  
Prebiotic Evolution  
199-52-22 W93-70247  
Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254
- PLANETARY SYSTEMS**  
Astrometric Imaging Telescope  
157-03-70 W93-70171  
Advanced Infrared Astronomy  
196-41-54 W93-70220
- PLANETARY TEMPERATURE**  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142
- PLANETARY WAVES**  
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
578-40-00 W93-70441
- PLANETOLOGY**  
Planetology  
151-01-70 W93-70139  
Windows on Global Change  
665-82-03 W93-70503
- PLANETS**  
Solar System Studies  
151-01-60 W93-70138  
Planetology  
151-01-70 W93-70139  
Planetary Instrument Definition and Development  
157-03-50 W93-70169  
Astrometric Imaging Telescope  
157-03-70 W93-70171  
Ground-Based Infrared Astronomy  
196-41-50 W93-70218  
Volatiles in the Solar System  
196-41-67 W93-70221  
Prebiotic Evolution  
199-52-22 W93-70247  
Solar System Exploration  
199-52-52 W93-70249  
Two-Phase Nebulae  
452-22-93 W93-70304  
Origins of Solar Systems  
452-23-94 W93-70305
- PLANKTON**  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- PLANNING**  
Global Change  
579-97-00 W93-70475
- PLANTS (BOTANY)**  
Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253  
Visiting Scientists  
462-76-49 W93-70353
- PLASMA ACCELERATORS**  
Propulsion Research and Technology  
506-42-00 W93-70070
- PLASMA DIAGNOSTICS**  
Solar Physics Studies  
170-38-53 W93-70181
- PLASMA HEATING**  
Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178  
Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180  
Sounding Rocket Experiments  
879-11-38 W93-70522
- PLASMA INTERACTION EXPERIMENT**  
Space Flight Research and Technology  
506-48-00 W93-70078  
Space Flight Research and Technology  
506-48-00 W93-70080  
Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178
- PLASMA INTERACTIONS**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292  
Neptune Data Analysis  
889-59-00 W93-70524
- PLASMA PHYSICS**  
Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178  
Space Physics Theory Program  
431-06-00 W93-70291  
Magnetospheric Coupling  
432-36-00 W93-70293  
Interdisciplinary ATD Studies  
433-04-00 W93-70295  
Space Physics Program Support/Detailees  
433-90-00 W93-70297  
Sounding Rockets: Space Plasma Physics Experiments  
435-11-00 W93-70298
- PLASMA RADIATION**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064
- PLASMA WAVES**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Magnetospheric Coupling  
432-36-00 W93-70293
- PLASMAS (PHYSICS)**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178  
Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180  
Solar Physics Studies  
170-38-53 W93-70181  
Theoretical Studies of Active Galaxies and Quasi-Stellar Objects (QSOs)  
188-46-01 W93-70204  
Magnetospheric Coupling  
432-36-00 W93-70293
- PLASMASPHERE**  
Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions  
432-48-00 W93-70294
- PLASTIC DEFORMATION**  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408
- PLASTIC PROPERTIES**  
Structural Biosystems  
199-40-42 W93-70242
- PLATEAUS**  
Validations of Passive Microwave Snow Water Equivalent Algorithm  
461-13-00 W93-70319
- PLATES (TECTONICS)**  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389  
Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391  
Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
465-13-06 W93-70392  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409
- PLUMES**  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413
- POINT SOURCES**  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206
- POINTING CONTROL SYSTEMS**  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542
- POISSON RATIO**  
Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399
- POLAR CAPS**  
Windows on Global Change  
665-82-03 W93-70503
- POLAR METEOROLOGY**  
Stratospheric Processes and Atmospheric Chemistry Studies  
464-14-00 W93-70373  
Microwave Temperature Profiler  
464-14-20 W93-70374  
Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450
- POLAR REGIONS**  
Automated Geophysical Processor Development for the Alaska SAR Facility  
428-82-11 W93-70273  
Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions  
432-48-00 W93-70294  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360  
Stratospheric Processes and Atmospheric Chemistry Studies  
464-14-00 W93-70373  
Homogeneous and Heterogeneous Processes of Atmospheric Interest  
464-21-05 W93-70377  
Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452  
Windows on Global Change  
665-82-03 W93-70503
- POLAR WANDERING (GEOLOGY)**  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460  
Rapid Earth Orientation Changes  
579-36-10 W93-70462  
Core-Mantle Excitation  
579-36-11 W93-70463
- POLARIMETERS**  
Space Data Systems  
586-03-00 W93-70136  
Imaging Spectropolarimeter  
157-03-70 W93-70170  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Interferometric Topography  
465-67-04 W93-70419
- POLARIMETRY**  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Polarimetric Data Analysis  
461-64-11 W93-70334

Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420

**POLARIZATION CHARACTERISTICS**  
Imaging Spectropolarimeter  
157-03-70 W93-70170  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333

**POLARIZED LIGHT**  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346

**POLICIES**  
Information Systems Newsletter  
656-50-65 W93-70477  
Planetary Hardcopy Preservation Task  
656-61-20 W93-70486

**POLLUTION CONTROL**  
Atmospheric Effects  
537-01-00 W93-70052  
Emissions and Source Noise  
537-02-00 W93-70053

**POLLUTION MONITORING**  
ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems  
665-35-00 W93-70499

**POLLUTION TRANSPORT**  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454  
ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems  
665-35-00 W93-70499

**POLYCRYSTALS**  
Electronic Materials  
674-21-08 W93-70506

**POLYMER CHEMISTRY**  
Materials and Structures Research and Technology  
506-43-00 W93-70073

**POLYMER MATRIX COMPOSITES**  
Materials and Structures Research and Technology  
506-43-00 W93-70074

**PORTABLE LIFE SUPPORT SYSTEMS**  
Human Support Research and Technology  
506-71-00 W93-70093

**POSEIDON SATELLITE**  
Goldstone DOSE Support  
465-28-02 W93-70403  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Large Scale Air-Sea Interactions  
578-22-26 W93-70433

**POSITION (LOCATION)**  
Parkfield GPS Experiment  
465-13-08 W93-70393  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439

**POSITIONING**  
Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328

**POSTURE**  
Neuroscience (Biomedical)  
199-16-12 W93-70234

**POTABLE WATER**  
Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254

**POTASSIUM**  
Observations of the Moon, Mercury, and Primitive Asteroids  
196-41-03 W93-70217

**POTENTIAL ENERGY**  
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190

**POWER CONDITIONING**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70065

**POWER CONVERTERS**  
Earth-Orbiting Platforms  
585-03-00 W93-70124

**PRE-MAIN SEQUENCE STARS**  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303

**PREAMPLIFIERS**  
Space Communications Research and Technology  
506-72-00 W93-70098

**PRECAMBRIAN PERIOD**  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391

**PRECESSION**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Theory of Geodetic Transformations  
465-15-06 W93-70398  
Advanced Magnetometer  
465-31-01 W93-70404

**PRECIPITATION (METEOROLOGY)**  
Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158  
Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
428-81-10 W93-70263  
Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277  
GEWEX Program Support  
461-50-03 W93-70331  
Airborne Precipitation Radar  
461-51-16 W93-70332

**PRECISION**  
Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328

**PREDICTION ANALYSIS TECHNIQUES**  
Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Aerodynamics Research and Technology  
505-59-00 W93-70003  
Materials and Structures Research and Technology  
505-63-00 W93-70008  
Materials and Structures Research and Technology  
505-63-00 W93-70009  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
Advanced Rotorcraft Technology  
532-06-00 W93-70040  
Advanced Turboprop Systems  
535-03-00 W93-70045  
Emissions and Source Noise  
537-02-00 W93-70054  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Community Noise and Sonic Boom  
537-03-00 W93-70057  
Enabling Propulsion Materials  
537-04-00 W93-70058  
Aging Aircraft  
538-02-00 W93-70061  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063  
Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Flight Dynamics Technology  
310-10-26 W93-70528

**PREDICTIONS**  
Laboratory Astrophysics  
188-44-57 W93-70201  
Planet-Forming Disks  
452-21-93 W93-70302

**PRESERVING**  
Planetary Materials: Collection, Preservation and Distribution  
152-20-40 W93-70149  
Planetary Hardcopy Preservation Task  
656-61-20 W93-70486

**PRESSURE DEPENDENCE**  
Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

**PRESSURE DISTRIBUTION**  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141

**PRESSURE MEASUREMENT**  
Spectral and Physical Properties of Planetary Atmospheric Constituents  
154-50-80 W93-70156  
Micro Weather Stations for Mars  
157-04-80 W93-70174

**PRESSURE RATIO**  
GA/Commuter Engine Technology  
535-05-00 W93-70046

**PRESSURE SUITS**  
Human Support Research and Technology  
506-71-00 W93-70093

**PRINTERS**  
Planetary Hardcopy Preservation Task  
656-61-20 W93-70486

**PROBABILITY THEORY**  
Automation and Robotics  
586-02-00 W93-70127  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222  
GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391

**PROCUREMENT**  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Management Support: Origins of Solar Systems Research Program  
452-89-91 W93-70307  
JPL Oceanography Group Common Computer System  
578-22-27 W93-70434  
Advanced Space Systems for Users of NASA Networks  
310-20-46 W93-70537

**PRODUCTIVITY**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
Optical Stellar Interferometry  
188-41-21 W93-70184  
DSN Data Processing and Productivity  
310-40-73 W93-70551

**PROGRAM VERIFICATION (COMPUTERS)**  
Automation and Robotics  
586-02-00 W93-70132

**PROGRAMMERS**  
LTP Visualization  
578-97-53 W93-70449  
LTP Computer Support  
579-41-04 W93-70465

**PROGRAMMING LANGUAGES**  
Data Interchange Standards  
656-61-03 W93-70479  
Construction of an Advanced Software Tool for Planetary Atmospheric Modeling  
656-65-24 W93-70494

**PROGRAMS**  
Interdisciplinary Technology  
506-90-00 W93-70108

**PROJECT MANAGEMENT**  
Space Flight Research and Technology  
506-48-00 W93-70081  
In-Space Technology Experiments  
506-74-00 W93-70106  
Planetary Materials: General Operations and Laboratory Facilities  
152-30-40 W93-70150  
IPAC Astrophysics Data System (ADS) Support  
399-20-00 W93-70258  
Space Physics Program Support/Detailees  
433-90-00 W93-70297  
Airborne Science Management Operating Working Group Support  
462-79-00 W93-70354  
Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418  
LTP Visualization  
578-97-53 W93-70449  
Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459  
Global Change  
579-97-00 W93-70475  
Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491

**PROJECT PLANNING**  
Earth and Space Sciences  
509-20-00 W93-70035  
Systems Analysis  
506-49-00 W93-70082  
Information and Communications  
586-02-00 W93-70134  
Information and Communications  
586-03-00 W93-70137  
Flight Research  
199-40-62 W93-70243  
Global Change  
579-97-00 W93-70475

**PROPELLANT COMBUSTION**  
Emissions and Source Noise  
537-02-00 W93-70053  
Emissions and Source Noise  
537-02-00 W93-70054  
In-Space Technology Experiments  
506-74-00 W93-70103



**PROPELLANT TANKS**

In-Space Technology Experiments  
506-74-00 W93-70103  
Earth-to-Orbit Transportation  
584-03-00 W93-70120

**PROPELLANTS**

Propulsion Research and Technology  
506-42-00 W93-70068  
Propulsion Research and Technology  
506-42-00 W93-70069  
Earth-to-Orbit Transportation  
584-03-00 W93-70118

**PROPELLER FANS**

Advanced Turboprop Systems  
535-03-00 W93-70045

**PROPELLERS**

Advanced Turboprop Systems  
535-03-00 W93-70044  
Advanced Turboprop Systems  
535-03-00 W93-70045

**PROPORTIONAL COUNTERS**

High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210

**PROPULSION**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Interdisciplinary Technology  
505-90-00 W93-70026  
Computational Aerosciences  
509-10-00 W93-70030  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
High-Performance Flight Research  
533-02-00 W93-70041  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Propulsion Research and Technology  
506-42-00 W93-70069

**PROPULSION SYSTEM CONFIGURATIONS**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Propulsion and Power  
505-62-00 W93-70005  
Systems Analysis  
505-69-00 W93-70018  
Systems Analysis  
505-69-00 W93-70019  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Hypersonic Research and Technology  
505-70-00 W93-70022  
Hypersonic Research and Technology  
505-70-00 W93-70023  
Interdisciplinary Technology  
505-90-00 W93-70026  
Computational Aerosciences  
509-10-00 W93-70030  
Computational/Aeroscience  
509-10-00 W93-70031  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
High-Performance Flight Research  
533-02-00 W93-70041  
Advanced Turboprop Systems  
535-03-00 W93-70045  
Atmospheric Effects  
537-01-00 W93-70051  
Enabling Propulsion Materials  
537-04-00 W93-70058  
Propulsion Research and Technology  
506-42-00 W93-70068  
Propulsion Research and Technology  
506-42-00 W93-70070  
Materials and Structures Research and Technology  
506-43-00 W93-70073  
System Analysis  
506-49-00 W93-70083  
Hypersonics Research and Technology  
506-73-00 W93-70100  
Hypersonic Research and Technology  
506-73-00 W93-70101  
In-Space Experiments  
506-74-00 W93-70105  
Earth-to-Orbit Transportation  
584-03-00 W93-70118  
Earth-to-Orbit Transportation  
584-03-00 W93-70120  
Earth-to-Orbit Transportation  
584-03-00 W93-70121  
Space Transportation  
584-04-00 W93-70122  
Space Transportation  
584-04-00 W93-70123

**PROPULSION SYSTEM PERFORMANCE**

Applied Aerodynamics Research and Technology  
505-59-00 W93-70001

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Propulsion and Power  
505-62-00 W93-70005  
Systems Analysis  
505-69-00 W93-70018  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Hypersonic Research and Technology  
505-70-00 W93-70022  
Interdisciplinary Technology  
505-90-00 W93-70026  
Computational Aerosciences  
509-10-00 W93-70030  
Computational/Aeroscience  
509-10-00 W93-70031  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
High-Performance Flight Research  
533-02-00 W93-70041  
Advanced Turboprop Systems  
535-03-00 W93-70045  
Emissions and Source Noise  
537-02-00 W93-70054  
Propulsion Research and Technology  
506-42-00 W93-70070  
Materials and Structures Research and Technology  
506-43-00 W93-70073  
System Analysis  
506-49-00 W93-70083  
In-Space Experiments  
506-74-00 W93-70105  
Earth-to-Orbit Transportation  
584-03-00 W93-70118  
Earth-to-Orbit Transportation  
584-03-00 W93-70121  
Space Transportation  
584-04-00 W93-70122  
Space Transportation  
584-04-00 W93-70123  
**PROTOBIOLOGY**  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252  
**PROTOCOL (COMPUTERS)**  
Space Data Systems  
586-03-00 W93-70136  
Networks Communication Technology  
310-20-38 W93-70536  
**PROTONS**  
Materials and Structures Research and Technology  
506-43-00 W93-70076  
Laboratory Astrophysics  
188-44-57 W93-70203  
Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521  
**PROTOSTARS**  
Solar System Studies  
151-01-60 W93-70138  
Submillimeter Astronomy  
188-44-23 W93-70194  
Center for Star Formation Studies  
399-20-01 W93-70260  
Planet-Forming Disks  
452-21-93 W93-70302  
**PROTOTYPES**  
Computational Aerosciences  
509-10-00 W93-70029  
Emissions and Source Noise  
537-02-00 W93-70054  
Human Support Research and Technology  
506-71-00 W93-70093  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70130  
Astrometric Imaging Telescope  
157-03-70 W93-70171  
Telepresence for Planetary Exploration  
186-06-01 W93-70182  
Process Studies: Radiation Dynamics and Hydrology,  
Radiation and Dynamic Processes  
460-20-00 W93-70308  
Atmospheric Parameter Mapping  
578-12-21 W93-70428  
Graphical Methods for Science Visualization and Data  
Analysis  
656-65-05 W93-70489

DataHub - Knowledge-Based Assistance for Science  
Visualization and Analysis Using Large Distributed  
Databases  
656-65-21 W93-70492  
A Distributed Analysis and Visualization System for  
Model and Observational Data  
656-65-27 W93-70497  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504  
Networks Communication Technology  
310-20-38 W93-70536  
Expert Systems for Automation of Operations  
310-40-47 W93-70547  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549  
**PROVING**  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355  
Expert Systems for Automation of Operations  
310-40-47 W93-70547  
**PSYCHOLOGY**  
Behavior and Performance Research  
199-06-11 W93-70230  
**PSYCHOMOTOR PERFORMANCE**  
Neuroscience (Biomedical)  
199-16-12 W93-70234  
**PSYCHOPHYSIOLOGY**  
Behavior and Performance Research  
199-06-11 W93-70230  
**PULSARS**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
**PULSE POSITION MODULATION**  
Space Communications Research and Technology  
506-72-00 W93-70098  
**PULSED LASERS**  
Airborne Doppler Lidar  
460-21-52 W93-70311  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358  
**PURIFICATION**  
Biotechnology  
674-23-08 W93-70509

**Q****QUADRATIC PROGRAMMING**

Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399

**QUADRUPLES**

A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143

**QUALIFICATIONS**

Space Flight Research and Technology  
506-48-00 W93-70080  
Surface Systems  
583-02-00 W93-70116

**QUALITY CONTROL**

Automation and Robotics  
586-02-00 W93-70132

**QUANTUM CHEMISTRY**

Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246

**QUANTUM EFFICIENCY**

Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188

**QUANTUM MECHANICS**

Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381  
Measurement of Volcanic Gases  
465-44-05 W93-70414

**QUANTUM WELLS**

Observatory Systems  
582-04-00 W93-70115

**QUASARS**

Deep Optical/UV Imaging of Quasars Below the Lyman  
Limit  
188-41-21 W93-70183  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197  
Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210  
HIPPARCOS VLBI  
399-18-00 W93-70256  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328

## R

## RADAR ANTENNAS

Airborne Interferometric Topography  
462-74-01 W93-70350

## RADAR ASTRONOMY

Advanced Transmitter Systems Development  
310-20-64 W93-70538

## RADAR CORNER REFLECTORS

ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502

## RADAR CROSS SECTIONS

Altimeter Measurements of Wind Speed and Sea Level  
Height With Applications to Air-Sea Interaction Studies:  
Physical Principles and Advanced Techniques  
461-33-02 W93-70325  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348

## RADAR DATA

Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Polarimetric Data Analysis  
461-64-11 W93-70334  
ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499

## RADAR IMAGERY

Automated Geophysical Processor Development for the  
Alaska SAR Facility  
428-82-11 W93-70273  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Airborne Interferometric Topography  
462-74-01 W93-70350  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
465-68-01 W93-70420  
Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate  
578-35-02 W93-70439  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
Geographical Information System for Fusion and  
Analysis of High-Resolution Remote Sensing and Ground  
Truth Data  
656-65-22 W93-70493  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504

## RADAR MAPS

Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Interferometric Topography  
465-67-04 W93-70419

## RADAR MEASUREMENT

CO2 Lidar Backscatter Experiment  
460-21-00 W93-70309  
Airborne Doppler Lidar  
460-21-52 W93-70311  
Wind Measurement Assessment  
460-28-41 W93-70314  
Scatterometer Research  
461-31-09 W93-70323  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410

## RADAR NETWORKS

Airborne Interferometric Topography  
462-74-01 W93-70350

## RADAR RECEIVERS

Science Sensing (Remote)  
582-03-00 W93-70113

## RADAR SCATTERING

Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348

## RADAR SIGNATURES

ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

## RADAR TARGETS

Lidar Target Calibration Facility  
460-22-52 W93-70312  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504

## RADAR TRACKING

Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185

## RADARSAT

Automated Geophysical Processor Development for the  
Alaska SAR Facility  
428-82-11 W93-70273  
Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Active/Passive Sea Ice Analysis  
578-32-24 W93-70437  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440

## RADIANCE

Thermal Infrared Science Support  
462-75-74 W93-70352  
AVIRIS Operations  
465-65-01 W93-70417  
Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

## RADIANT COOLING

Planetary Instrument Development Program/Planetary  
Astronomy High Temperature Superconductor  
Bolometers  
157-05-50 W93-70175

## RADIANT FLUX DENSITY

EOS Science  
429-81-38 W93-70281

## RADIATION ABSORPTION

Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315

## RADIATION DAMAGE

Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Optical Technology for Space Astronomy  
188-41-23 W93-70186  
Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226  
Space Radiation  
199-04-14 W93-70228  
**RADIATION DETECTORS**  
Science Sensing (Remote)  
582-03-00 W93-70109  
Science Sensing (Remote)  
582-03-00 W93-70110  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210  
Integral Mission Definition Study  
188-78-01 W93-70211  
Gravity Wave Mission Definition Study  
188-78-01 W93-70212

## RADIATION DISTRIBUTION

Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315

## RADIATION DOSAGE

In-Space Technology Experiments  
506-74-00 W93-70106  
Science Sensing (Remote)  
582-03-00 W93-70111  
Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226

## RADIATION EFFECTS

Materials and Structures Research and Technology  
506-43-00 W93-70076  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143

Laboratory Astrophysics  
188-44-57 W93-70201  
Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226  
Space Radiation  
199-04-14 W93-70228

## RADIATION PROTECTION

Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225

## RADIATION SHIELDING

In-Space Technology Experiments  
506-74-00 W93-70106  
Radiation Health  
199-04-11 W93-70226

## RADIATION SOURCES

Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196

## RADIATIVE HEAT TRANSFER

EOS Science  
429-81-38 W93-70281  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316

## RADIATIVE TRANSFER

Planetary Atmospheric Composition, Structure, and  
History  
154-10-80 W93-70152  
Mars Surface and Atmosphere Studies  
155-04-00 W93-70162  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
Two-Phase Nebulae  
452-22-93 W93-70304  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
Heterogeneous Scene Models  
462-61-03 W93-70347  
Measurement of Volcanic Gases  
465-44-05 W93-70414  
Climate Modeling with Emphasis on Aerosols and  
Clouds  
578-11-01 W93-70422  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468  
Soil/Canopy Moisture and Temperature Profiles Using  
Remote Sensing and Modeling  
579-42-13 W93-70471  
Windows on Global Change  
665-82-03 W93-70503  
Neptune Data Analysis Program  
889-59-00 W93-70526

## RADICALS

Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373

## RADIO ALTIMETERS

Large Scale Air-Sea Interactions  
578-22-26 W93-70433  
Radar-Altimeter Ice Data System  
578-97-20 W93-70448

## RADIO ASTRONOMY

Infrared/Radio Research  
188-44-21 W93-70193  
Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195

- Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196
- RADIO COMMUNICATION**  
Systems Analysis  
505-69-00 W93-70017  
Space Communications Research and Technology  
506-72-00 W93-70099  
Mars 94 Winds  
155-20-04 W93-70168  
Radio Systems Development  
310-20-66 W93-70540
- RADIO EMISSION**  
HIPPARCOS VLBI  
399-18-00 W93-70256  
Neptune Data Analysis  
889-59-00 W93-70524
- RADIO EQUIPMENT**  
Space Communications Research and Technology  
506-72-00 W93-70096
- RADIO FREQUENCIES**  
Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Optical Communications  
310-20-35 W93-70533  
Advanced Space Systems for Users of NASA Networks  
310-20-46 W93-70537  
Antenna Systems Development  
310-20-65 W93-70539  
Network Signal Processing  
310-30-70 W93-70543
- RADIO FREQUENCY INTERFERENCE**  
Radio Systems Development  
310-20-66 W93-70540
- RADIO GALAXIES**  
HIPPARCOS VLBI  
399-18-00 W93-70256
- RADIO JETS (ASTRONOMY)**  
Simulations of Compact Radio Sources  
188-44-53 W93-70198
- RADIO NAVIGATION**  
Space Systems and Navigation Technology  
310-10-63 W93-70532
- RADIO OBSERVATION**  
Infrared/Radio Research  
188-44-21 W93-70193
- RADIO OCCULTATION**  
U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166  
Neptune Data Analysis Program  
889-59-00 W93-70526
- RADIO RECEIVERS**  
Science Sensing (Remote)  
582-03-00 W93-70112  
Submillimeter Astronomy  
188-44-23 W93-70194  
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar  
188-44-24 W93-70197
- RADIO SIGNALS**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177
- RADIO SOURCES (ASTRONOMY)**  
Theory and Modeling: Infrared, Submillimeter, and Radio  
188-44-53 W93-70200
- RADIO STARS**  
HIPPARCOS VLBI  
399-18-00 W93-70256
- RADIO TELESCOPES**  
Magnetospheric Coupling  
432-36-00 W93-70293
- RADIO TRACKING**  
Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151  
Mars 94 Gravity  
155-20-03 W93-70167  
Astrometric Development Technology  
310-10-60 W93-70529
- RADIOACTIVE DECAY**  
Planetary Materials: Geochronology  
152-14-40 W93-70146
- RADIOACTIVE ISOTOPES**  
Planetary Materials: Geochronology  
152-14-40 W93-70146
- RADIOACTIVITY**  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147
- RADIOBIOLOGY**  
Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225  
Radiation Health  
199-04-11 W93-70226  
Space Radiation  
199-04-14 W93-70228
- RADIOMETERS**  
Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363  
MM and Sub-MM Radiometry  
464-12-06 W93-70369  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383  
AVIRIS Operations  
465-65-01 W93-70417  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542
- RADIOSONDES**  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
GPS/VLBI Vertical Measurement  
465-14-09 W93-70396  
Meteorological Parameters Extraction  
578-12-20 W93-70427
- RADON**  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454
- RAIN**  
Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
428-81-10 W93-70263  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Biogeochemistry and Geophysics Modeling and Data Analysis  
579-42-01 W93-70467  
Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
656-65-22 W93-70493
- RAMAN SPECTRA**  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371
- RAMJET ENGINES**  
Hypersonic Research and Technology  
505-70-00 W93-70022
- RANDOM ACCESS MEMORY**  
Information and Communications  
586-03-00 W93-70137
- RANGEFINDING**  
Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Stratospheric Observatory for Infrared Astronomy (SOFIA)  
188-78-60 W93-70216  
Visiting Scientists  
462-76-49 W93-70353  
Lateral Variations in Solid Tides  
465-17-04 W93-70401
- RAPID QUENCHING (METALLURGY)**  
Metals and Alloys  
674-25-08 W93-70514
- RARE EARTH COMPOUNDS**  
Surface Systems  
583-02-00 W93-70117
- RARE GASES**  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147
- RATES (PER TIME)**  
Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions  
370-03-00 W93-70255
- RATS**  
Structural Biosystems  
199-40-42 W93-70242
- REACTION KINETICS**  
Emissions and Source Noise  
537-02-00 W93-70053  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062  
Materials and Structures Research and Technology  
506-43-00 W93-70077  
A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains  
152-12-40 W93-70143  
Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals  
154-75-80 W93-70159  
Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376  
Homogeneous and Heterogeneous Processes of Atmospheric Interest  
464-21-05 W93-70377  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379  
Data Survey and Evaluation  
464-41-04 W93-70385  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386
- REACTION PRODUCTS**  
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383
- REACTIVITY**  
Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376  
Fluid Physics  
674-24-00 W93-70510
- READ-ONLY MEMORY DEVICES**  
Atmospheric Parameter Mapping  
578-12-21 W93-70428  
Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450  
PDS: Data Distribution and Archive Technology  
656-61-06 W93-70481  
Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490
- REAL GASES**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063
- REAL TIME OPERATION**  
Materials and Structures Research and Technology  
505-63-00 W93-70006  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Information and Controls Research and Technology  
506-59-00 W93-70092  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498
- RECEIVERS**  
Space Communications Research and Technology  
506-72-00 W93-70098  
Earth-Orbiting Platforms  
585-03-00 W93-70124  
Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328  
North American Fiducial Network  
465-14-11 W93-70397  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542
- RED ARCS**  
Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions  
432-48-00 W93-70294
- RED SHIFT**  
Deep Optical/UV Imaging of Quasars Below the Lyman Limit  
188-41-21 W93-70183

**REDUCED GRAVITY**

Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Information and Controls Research and Technology  
506-59-00 W93-70087  
In-Space Experiments  
506-74-00 W93-70102  
In-Space Technology Experiments  
506-74-00 W93-70103  
In-Space Technology Experiments  
506-74-00 W93-70104  
In-Space Experiments  
506-74-00 W93-70105  
In-Space Technology Experiments  
506-74-00 W93-70107  
Automation and Robotics  
586-02-00 W93-70129  
Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148  
Longitudinal Studies (Medical Operations Longitudinal  
Studies)  
199-02-31 W93-70224  
General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232  
Cardiopulmonary Physiology  
199-14-12 W93-70233  
Neuroscience (Biomedical)  
199-16-12 W93-70234  
Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237  
Cell and Development Biology  
199-40-21 W93-70239  
Cell and Developmental Biology  
199-40-22 W93-70240  
Flight Research  
199-40-62 W93-70243  
Data System Integration (Commonality and  
Interoperability)  
656-61-02 W93-70478  
SS Freedom Archive Planning Study  
656-61-13 W93-70483  
Electronic Materials  
674-21-05 W93-70505  
Electronic Materials  
674-21-08 W93-70506  
Combustion Science  
674-22-05 W93-70507  
Biotechnology Research  
674-23-01 W93-70508  
Biotechnology  
674-23-08 W93-70509  
Fluid Physics  
674-24-00 W93-70510  
Fluid Physics  
674-24-05 W93-70511  
Metals and Alloys  
674-25-05 W93-70513  
Glasses and Ceramics  
674-26-05 W93-70515  
Glasses and Ceramics  
674-26-08 W93-70516  
Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517  
Ground Experiment Operations  
674-28-05 W93-70518  
Ground Experiment Operations  
674-28-08 W93-70519  
Consulting and Program Support  
674-29-08 W93-70520

**REDUNDANT COMPONENTS**  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060

**REENTRY VEHICLES**  
Materials and Structures Research and Technology  
506-43-00 W93-70071

**REFINING**  
Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409

**REFLECTANCE**  
Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217  
Lidar Target Calibration Facility  
460-22-52 W93-70312  
Laser Induced Fluorescence: A Technique for Remote  
Assessment of Photosynthetic Efficiency and Detection  
of Environmental Stress  
462-31-63 W93-70339

Biospheric/Atmospheric Interactions  
463-67-00 W93-70362

**REFLECTORS**  
Materials and Structures Research and Technology  
506-43-00 W93-70075

**REFRACTIVITY**  
Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495  
Astrometric Development Technology  
310-10-60 W93-70529

**REFRACTORIES**  
Laboratory Astrophysics  
188-44-57 W93-70203

**REFRACTORY MATERIALS**  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
Enabling Propulsion Materials  
537-04-00 W93-70058  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143  
Microgravity Nucleation and Particle Coagulation  
Experiments  
152-20-01 W93-70148  
Solar Probe ATD  
433-06-00 W93-70296

**REFRACTORY METALS**  
Materials and Structures Research and Technology  
506-43-00 W93-70074

**REFRIGERATORS**  
Observatory Systems  
582-04-00 W93-70114  
Observatory Systems  
582-04-00 W93-70115  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206

**REGENERATION (ENGINEERING)**  
Human Support Research and Technology  
506-71-00 W93-70093

**REGOLITH**  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Neptune Data Analysis Program  
889-59-00 W93-70526

**REGRESSION ANALYSIS**  
Retracking of Topex Waveform Data  
461-34-01 W93-70326

**RELATIVISTIC THEORY**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185

**RELATIVITY**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185

**RELAY SATELLITES**  
Space Communications Research and Technology  
506-72-00 W93-70096  
Space Communications Research and Technology  
506-72-00 W93-70098  
Optical Communications  
310-20-35 W93-70533  
Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549

**RELIABILITY**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036  
Advanced Composite Materials Technology  
510-02-00 W93-70037  
Advanced Turboprop Systems  
535-03-00 W93-70044  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Materials and Structures Research and Technology  
506-43-00 W93-70073  
Earth-to-Orbit Transportation  
584-03-00 W93-70118  
Space Transportation  
584-04-00 W93-70123  
Advanced Transmitter Systems Development  
310-20-64 W93-70538  
Antenna Systems Development  
310-20-65 W93-70539  
Radio Systems Development  
310-20-66 W93-70540

**RELIABILITY ENGINEERING**  
Controls, Guidance, and Human Factors Research and  
Technology  
505-64-00 W93-70010  
Surface Systems  
583-02-00 W93-70116

**RELIEF MAPS**

Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Topography from SEASAT and GEOSAT Overland  
Altimetry  
579-42-03 W93-70469  
ASF SAR Interferometry  
665-35-01 W93-70500

**REMOTE CONTROL**  
Automation and Robotics  
586-02-00 W93-70129

**REMOTE SENSING**  
Earth and Space Sciences  
509-20-00 W93-70035  
Science Sensing (Remote)  
582-03-00 W93-70109  
Science Sensing (Remote)  
582-03-00 W93-70110  
Science Sensing (Remote)  
582-03-00 W93-70111  
Science Sensing (Remote)  
582-03-00 W93-70112  
Science Sensing (Remote)  
582-03-00 W93-70113  
Observatory Systems  
582-04-00 W93-70114  
Automation and Robotics  
586-02-00 W93-70130  
Planetary Instrument Definition and Development  
157-03-50 W93-70169  
Imaging Spectropolarimeter  
157-03-70 W93-70170  
Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Ocean Color Data System  
428-82-06 W93-70272  
Automated Geophysical Processor Development for the  
Alaska SAR Facility  
428-82-11 W93-70273  
Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274  
Role of Air-Sea Exchanges and Ocean Circulation  
(Science)  
429-81-10 W93-70277  
Project to Interface Modeling  
429-81-72 W93-70283  
Global Assessment of Active Volcanism  
429-81-94 W93-70285  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Foreign Visitor Support  
429-97-04 W93-70290  
Process Studies: Radiation Dynamics and Hydrology,  
Radiation and Dynamic Processes  
460-20-00 W93-70308  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Lidar Target Calibration Facility  
460-22-52 W93-70312  
Wind Measurement Assessment  
460-28-41 W93-70314  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315  
Hydrologic Processes, Field Study  
461-10-00 W93-70318  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Desert Mesoscale/PBL  
461-13-02 W93-70322  
Scatterometer Studies  
461-31-13 W93-70324  
Altimeter Measurements of Wind Speed and Sea Level  
Height With Applications to Air-Sea Interaction Studies:  
Physical Principles and Advanced Techniques  
461-33-02 W93-70325  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
TRMM  
461-38-05 W93-70329  
Hydrologic Process Studies  
461-50-00 W93-70330  
GEWEX Program Support  
461-50-03 W93-70331  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Oceanic Remote Sensing Library  
461-66-16 W93-70335

Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339

Land Surface Climatology: HAPEX  
462-32-00 W93-70340

Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341

ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342

Biogeochemical Cycling Research on the Oregon Transect  
462-43-00 W93-70344

Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345

Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348

Soil Moisture from SAR  
462-62-05 W93-70349

Airborne Synthetic Aperture Radar (AIRSAR) Operations  
462-75-62 W93-70351

Thermal Infrared Science Support  
462-75-74 W93-70352

Visiting Scientists  
462-76-49 W93-70353

Airborne Science Management Operating Working Group Support  
462-79-00 W93-70354

SeaWiFS Calibration/Validation  
463-11-01 W93-70355

Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356

Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357

Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359

Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361

Biospheric/Atmospheric Interactions  
463-67-00 W93-70362

Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363

AVIRIS Operations  
463-75-63 W93-70364

Ozone Measurements  
464-11-05 W93-70365

Laser Diode Sensor  
464-11-07 W93-70366

MM and Sub-MM Radiometry  
464-12-06 W93-70369

Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370

Multi-Sensor Balloon Measurements  
464-16-01 W93-70375

Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements  
464-23-08 W93-70381

ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407

Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408

Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409

Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411

Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413

Measurement of Volcanic Gases  
465-44-05 W93-70414

Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418

Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420

Experimental Cloud Analysis Techniques  
578-12-01 W93-70424

Active/Passive Sea Ice Analysis  
578-32-24 W93-70437

Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
578-40-00 W93-70441

Subgrid Variation of Surface Parameters  
578-42-15 W93-70444

Simulation of Tropospheric Ozone  
579-24-00 W93-70453

Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464

ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
579-42-13 W93-70471

Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
656-65-22 W93-70493

A Spatial Analysis and Modeling System for Environmental Management  
656-65-26 W93-70496

Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**REMOTE SENSORS**  
Information and Controls Research and Technology  
506-59-00 W93-70089

Science Sensing (Remote)  
582-03-00 W93-70110

Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317

SeaWiFS Calibration/Validation  
463-11-01 W93-70355

Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

**REPLACING**  
Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464

**RESCUE OPERATIONS**  
Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012

Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**RESEARCH AIRCRAFT**  
Flight Systems Research and Technology  
505-68-00 W93-70013

Community Noise and Sonic Boom  
537-03-00 W93-70056

Airborne Doppler Lidar  
460-21-52 W93-70311

Atmospheric Backscatter Experiment  
460-22-53 W93-70313

Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317

Airborne Science Management Operating Working Group Support  
462-79-00 W93-70354

Ozone Measurements  
464-11-05 W93-70365

**RESEARCH AND DEVELOPMENT**  
Interdisciplinary Technology  
505-90-00 W93-70024

Interdisciplinary Technology  
505-90-00 W93-70026

Interdisciplinary Technology  
505-90-00 W93-70027

Systems Analysis  
506-49-00 W93-70082

Interdisciplinary Technology  
506-90-00 W93-70108

Automation and Robotics  
586-02-00 W93-70127

Stratospheric Observatory for Infrared Astronomy (SOFIA)  
188-78-60 W93-70216

Flight Research  
199-40-62 W93-70243

Hydrologic Processes, Field Study  
461-10-00 W93-70318

Biotechnology  
674-23-08 W93-70509

Consulting and Program Support  
674-29-08 W93-70520

Software Engineering Technology  
310-10-23 W93-70527

Networks Communication Technology  
310-20-38 W93-70536

Optical Communications Technology Development  
310-20-67 W93-70541

**RESEARCH FACILITIES**  
NAS Operations  
536-02-00 W93-70048

Human Support Research and Technology  
506-71-00 W93-70095

Automation and Robotics  
586-02-00 W93-70129

Planetary Materials: General Operations and Laboratory Facilities  
152-30-40 W93-70150

Research Computing Facility and Cataloging for Infrared  
188-44-01 W93-70192

Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418

LTP Computer Support  
579-41-04 W93-70465

Consulting and Program Support  
674-29-08 W93-70520

**RESEARCH MANAGEMENT**  
Process Studies: Radiation Dynamics and Hydrology, Radiation and Dynamic Processes  
460-20-00 W93-70308

PDS: Data Distribution and Archive Technology  
656-61-06 W93-70481

Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491

**RESEARCH PROJECTS**  
Interdisciplinary Technology  
506-90-00 W93-70108

Airborne Science Management Operating Working Group Support  
465-66-00 W93-70418

Consulting and Program Support  
674-29-08 W93-70520

**RESEARCH VEHICLES**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039

Space Flight Research and Technology  
506-48-00 W93-70079

**RESIN MATRIX COMPOSITES**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036

**RESONANCE FLUORESCENCE**  
Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals  
154-75-80 W93-70159

Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190

Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376

**RESONANT VIBRATION**  
Automation and Robotics  
586-02-00 W93-70133

**RESONATORS**  
Frequency and Timing Research  
310-10-62 W93-70531

**RESOURCE ALLOCATION**  
Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151

Airborne Science Management Operating Working Group Support  
462-79-00 W93-70354

**RESOURCES MANAGEMENT**  
Earth and Space Sciences  
509-20-00 W93-70032

**RESTORATION**  
Data Management Initiative - National Space Science Data Center  
656-61-21 W93-70487

**RETROREFLECTORS**  
Optical Communications  
310-20-35 W93-70533

**REUSABLE LAUNCH VEHICLES**  
Hypersonic Research and Technology  
505-70-00 W93-70023

Hypersonic Research and Technology  
506-73-00 W93-70101

**REUSABLE ROCKET ENGINES**  
Earth-to-Orbit Transportation  
584-03-00 W93-70118

**REYNOLDS NUMBER**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063

**RHEOLOGY**  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460

**RISK**  
Advanced Composite Materials Technology  
510-02-00 W93-70037

In-Space Technology Experiments  
506-74-00 W93-70103

**ROBOT ARMS**  
Information and Controls Research and Technology  
506-59-00 W93-70092

**ROBOT CONTROL**  
Information and Controls Research and Technology  
506-59-00 W93-70087

**ROBOTICS**  
Information and Controls Research and Technology  
506-59-00 W93-70087

Information and Controls Research and Technology  
506-59-00 W93-70088  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Automation and Robotics  
586-02-00 W93-70127  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70129  
Automation and Robotics  
586-02-00 W93-70130  
Automation and Robotics  
586-02-00 W93-70131  
Automation and Robotics  
586-02-00 W93-70133  
Micro Weather Stations for Mars  
157-04-80 W93-70174  
Advanced Transmitter Systems Development  
310-20-64 W93-70538

**ROBOTS**

Automation and Robotics  
586-02-00 W93-70132  
Automation and Robotics  
586-02-00 W93-70133  
Telepresence for Planetary Exploration  
186-06-01 W93-70182

**ROCKET ENGINE DESIGN**

Earth-To-Orbit Transportation  
584-03-00 W93-70119

**ROCKET ENGINES**

Space Transportation  
584-04-00 W93-70122

**ROCKET FLIGHT**

High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210  
Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298

**ROCKET THRUST**

System Analysis  
506-49-00 W93-70083

**ROCKET-BORNE INSTRUMENTS**

X-Ray Astronomy CCD  
188-46-59 W93-70209  
Sounding Rocket Experiments  
879-11-38 W93-70522

**ROCKS**

Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials: Geochronology  
152-14-40 W93-70146

**ROCKY MOUNTAINS (NORTH AMERICA)**

Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416

**ROOM TEMPERATURE**

Space Energy Conversion Research and Technology  
506-41-00 W93-70066

**ROOT-MEAN-SQUARE ERRORS**

X-Ray Astronomy CCD  
188-46-59 W93-70209

**ROSAT MISSION**

High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205  
High Energy Astrophysics International Programs  
440-62-59 W93-70299

**ROTARY ENGINES**

Propulsion and Power Research and Technology  
505-62-00 W93-70004

**ROTARY WING AIRCRAFT**

Aerodynamics Research and Technology  
505-59-00 W93-70002  
Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Materials and Structures Research and Technology  
505-63-00 W93-70009  
Controls, Guidance, and Human Factors Research and  
Technology  
505-64-00 W93-70010  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
Advanced Rotorcraft Technology  
532-06-00 W93-70040  
GA/Commuter Engine Technology  
535-05-00 W93-70046

**ROTATING BODIES**

Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395

**ROTATING FLUIDS**

Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185

**ROTOR AERODYNAMICS**

Advanced Rotorcraft Technology  
532-06-00 W93-70040

**ROTORCRAFT AIRCRAFT**

Systems Analysis  
505-69-00 W93-70016

**ROTORS**

Advanced Rotorcraft Technology  
532-06-00 W93-70039

**ROVING VEHICLES**

Space Energy Conversion Research and Technology  
506-41-00 W93-70067

**RUN TIME (COMPUTERS)**

Automation and Robotics  
586-02-00 W93-70131

**S****S WAVES**

Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399  
Lateral Variations in Solid Tides  
465-17-04 W93-70401

**SAFETY**

Space Flight Research and Technology  
506-48-00 W93-70080  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Automation and Robotics  
586-02-00 W93-70133  
Information and Communications  
586-02-00 W93-70134  
Mission Operations Technology  
310-40-45 W93-70546

**SALINITY**

Airborne ESTAR  
461-38-01 W93-70327  
TRMM  
461-38-05 W93-70329

**SAMPLING**

Exobiology Intact Capture Technology Development  
199-52-54 W93-70250  
AVIRIS Operations  
465-65-01 W93-70417

**SAN ANDREAS FAULT**

Parkfield GPS Experiment  
465-13-08 W93-70393

**SAN MARCO SATELLITES**

Archival Task for the Equatorial San Marco D, AE and  
DE Satellite Missions  
370-03-00 W93-70255

**SANDWICH STRUCTURES**

Solar Probe ATD  
433-06-00 W93-70296

**SARSAT**

Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**SATELLITE ALTIMETRY**

Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Radar-Altimeter Ice Data System  
578-97-20 W93-70448  
Topography from SEASAT and GEOSAT Overland  
Altimetry  
579-42-03 W93-70469

**SATELLITE COMMUNICATION**

Space Communications Research and Technology  
506-72-00 W93-70097  
Space Communications Research and Technology  
506-72-00 W93-70099  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504  
Optical Communications  
310-20-35 W93-70533

**SATELLITE IMAGERY**

Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Atmospheric Parameter Mapping  
578-12-21 W93-70428

Monitoring the Seasonal Cycle of Sea Ice in the Arctic  
Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440

Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450  
Spatial and Temporal Distribution of Biomass  
Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472  
Landsat Land Cover Pathfinder  
579-98-00 W93-70476

**SATELLITE INSTRUMENTS**

Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355  
Global Tectonic Motions  
465-14-01 W93-70394  
Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395  
Soil/Canopy Moisture and Temperature Profiles Using  
Remote Sensing and Modeling  
579-42-13 W93-70471

**SATELLITE OBSERVATION**

UV Astronomy and Data Systems  
188-41-51 W93-70189  
Volatiles in the Solar System  
196-41-67 W93-70221  
Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)  
428-81-10 W93-70263  
Ocean Color Data System  
428-82-06 W93-70272  
Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274  
Interannual Variability of Global Cycles  
429-81-06 W93-70276  
EOS Science  
429-81-38 W93-70281  
Project to Interface Modeling  
429-81-72 W93-70283  
Global Assessment of Active Volcanism  
429-81-94 W93-70285  
Foreign Visitor Support  
429-97-04 W93-70290  
Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Hydrologic Processes, Field Study  
461-10-00 W93-70318  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Airborne Precipitation Radar  
461-51-16 W93-70332  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359  
Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384  
Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410  
Volcanic Cloud Dispersion, Chemistry and Microphysics:  
An Analysis of the El Chichon Eruption  
465-44-06 W93-70415  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Data Analysis  
578-10-00 W93-70421  
Experimental Cloud Analysis Techniques  
578-12-01 W93-70424  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425  
Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Global Monthly Mean Ocean Variability  
578-22-29 W93-70435  
Global Climate Modeling  
578-41-01 W93-70442  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

- Problems in Interpreting Satellite Crustal Anomaly Field Data  
579-31-01 W93-70456
- Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470
- Advanced Search and Rescue Techniques  
669-30-10 W93-70504
- SATELLITE SOUNDING**  
Meteorological Parameters Extraction  
578-12-20 W93-70427
- SATELLITE TRACKING**  
Optical Communications Technology Development  
310-20-67 W93-70541
- SATELLITE TRANSMISSION**  
Ozone Measurements  
464-11-05 W93-70365
- SATELLITE-BORNE INSTRUMENTS**  
Observatory Systems  
582-04-00 W93-70115
- Optical Technology for Space Astronomy  
188-41-23 W93-70186
- Laboratory Astrophysics  
188-44-57 W93-70201
- Landsat Land Cover Pathfinder  
579-98-00 W93-70476
- Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480
- SATELLITE-BORNE RADAR**  
ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems  
665-35-00 W93-70499
- Advanced Search and Rescue Techniques  
669-30-10 W93-70504
- SCALE HEIGHT**  
Global Assessment of Active Volcanism  
429-81-95 W93-70286
- ASF SAR Interferometry  
665-35-01 W93-70500
- SCALE MODELS**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039
- Advanced Turboprop Systems  
535-03-00 W93-70044
- SCALING LAWS**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039
- SCATTERING**  
Polarimetric Data Analysis  
461-64-11 W93-70334
- ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342
- SCATTERING COEFFICIENTS**  
Airborne Doppler Lidar  
460-21-52 W93-70311
- Lidar Target Calibration Facility  
460-22-52 W93-70312
- Atmospheric Backscatter Experiment  
460-22-53 W93-70313
- Satellite Radar for Forest Structure  
462-41-61 W93-70343
- SCATTEROMETERS**  
Role of Air-Sea Exchanges and Ocean Circulation (Computing)  
428-81-10 W93-70263
- Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277
- Scatterometer Research  
461-31-09 W93-70323
- Scatterometer Studies  
461-31-13 W93-70324
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- SCENE ANALYSIS**  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466
- SCHEDULING**  
Information and Controls Research and Technology  
506-59-00 W93-70088
- Automation and Robotics  
586-02-00 W93-70133
- Information and Communications  
586-02-00 W93-70134
- ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- Planning and Scheduling Systems Technology  
310-20-36 W93-70534
- SCHMIDT CAMERAS**  
Imaging Studies of Comets  
196-41-52 W93-70219
- SCHOOLS**  
Windows on Global Change  
665-82-03 W93-70503
- SCIENTIFIC SATELLITES**  
Geopotential Temporal Variations  
465-17-02 W93-70400
- SCIENTISTS**  
Research Computing Facility and Cataloging for Infrared  
188-44-01 W93-70192
- The Development of a Mid-Infrared Spectrometer for the Infrared Telescope in Space  
440-63-44 W93-70300
- Consulting and Program Support  
674-29-08 W93-70520
- SCINTILLATION**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177
- SCINTILLATION COUNTERS**  
Proposal for a High-Energy Imaging Device (HEIDI) on a Balloon  
879-11-48 W93-70523
- SEA ICE**  
Automated Geophysical Processor Development for the Alaska SAR Facility  
428-82-11 W93-70273
- Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282
- Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333
- Polarimetric Data Analysis  
461-64-11 W93-70334
- Active/Passive Sea Ice Analysis  
578-32-24 W93-70437
- Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438
- Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
- Modeling and Data Analysis, Climate and Hydrology Cryosphere Studies  
578-90-00 W93-70445
- Radar-Altimeter Ice Data System  
578-97-20 W93-70448
- Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501
- ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- SEA LEVEL**  
Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325
- Retracking of Topex Waveform Data  
461-34-01 W93-70326
- Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328
- Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430
- Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431
- SEA SURFACE TEMPERATURE**  
Role of Air-Sea Exchanges and Ocean Circulation (Science)  
429-81-10 W93-70277
- Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282
- IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284
- IR Remote Sensing of SST  
460-21-28 W93-70310
- Scatterometer Studies  
461-31-13 W93-70324
- Airborne ESTAR  
461-38-01 W93-70327
- Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- Meteorological Parameters Extraction  
578-12-20 W93-70427
- Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
- Climate Stability: The Role of the Hydrological Cycle and the Thermohaline Circulation  
578-31-14 W93-70436
- SEA WATER**  
Airborne ESTAR  
461-38-01 W93-70327
- SEAS**  
ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- SEASAT SATELLITES**  
Scatterometer Studies  
461-31-13 W93-70324
- Topography from SEASAT and GEOSAT Overland Altimetry  
579-42-03 W93-70469
- SEASONS**  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- SECULAR VARIATIONS**  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460
- SEDIMENTS**  
Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption  
465-44-06 W93-70415
- SEEBECK EFFECT**  
Surface Systems  
583-02-00 W93-70117
- SEISMIC WAVES**  
Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399
- Lateral Variations in Solid Tides  
465-17-04 W93-70401
- SEISMOLOGY**  
Dynamics of North American-Pacific Shear  
465-13-02 W93-70390
- GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391
- Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399
- Core-Mantle Excitation  
579-36-11 W93-70463
- SEMICONDUCTOR LASERS**  
Information and Controls Research and Technology  
506-59-00 W93-70091
- Space Communications Research and Technology  
506-72-00 W93-70098
- Information and Communications  
586-03-00 W93-70135
- Laboratory Astrophysics  
188-44-57 W93-70203
- Advanced Magnetometer  
465-31-01 W93-70404
- SEMICONDUCTORS (MATERIALS)**  
Information and Controls Research and Technology  
506-59-00 W93-70088
- Micro Weather Stations for Mars  
157-04-80 W93-70174
- Electronic Materials  
674-21-05 W93-70505
- SENSORS**  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060
- Astrotech 21  
188-78-44 W93-70215
- SEQUENCING**  
Optical Stellar Interferometry  
188-41-21 W93-70184
- Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409
- SERVICE LIFE**  
Enabling Propulsion Materials  
537-04-00 W93-70058
- Space Energy Conversion Research and Technology  
506-41-00 W93-70067
- Earth-to-Orbit Transportation  
584-03-00 W93-70118
- SHEAR STRESS**  
ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- SHIPS**  
Problems in Interpreting Satellite Crustal Anomaly Field Data  
579-31-01 W93-70456
- SHOCK WAVES**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177
- Center for Star Formation Studies  
399-20-01 W93-70260
- SHORELINES**  
Topography from SEASAT and GEOSAT Overland Altimetry  
579-42-03 W93-70469
- SHROUDED PROPELLERS**  
Advanced Turboprop Systems  
535-03-00 W93-70044



**SIDEBANDS**

Science Sensing (Remote)	
582-03-00	W93-70112
NDSC Microwave Instrument Support	
464-13-22	W93-70372
<b>SIGNAL ANALYSIS</b>	
Retracking of Topex Waveform Data	
461-34-01	W93-70326
<b>SIGNAL ANALYZERS</b>	
Network Signal Processing	
310-30-70	W93-70543
<b>SIGNAL MEASUREMENT</b>	
Short-Period Tropospheric Noise in Continuous GPS Measurements	
465-27-02	W93-70402
<b>SIGNAL PROCESSING</b>	
Relativity, Cosmology, and Gravitational Radiation	
188-41-22	W93-70185
Synthetic Aperture Microwave Radiometer	
462-26-01	W93-70338
ARISTOTELES GPS Receiver Development	
465-35-05	W93-70406
Network Signal Processing	
310-30-70	W93-70543
<b>SIGNAL RECEPTION</b>	
Space Communications Research and Technology	
506-72-00	W93-70099
Airborne Doppler Lidar	
460-21-52	W93-70311
<b>SIGNAL TO NOISE RATIOS</b>	
X-Ray Astronomy CCD	
188-46-59	W93-70209
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis	
656-65-25	W93-70495
Network Signal Processing	
310-30-70	W93-70543
<b>SIGNAL TRANSMISSION</b>	
Fly-By-Light/Power-By-Wire	
538-01-00	W93-70060
Wind Measurement Assessment	
460-28-41	W93-70314
Frequency and Timing Research	
310-10-62	W93-70531
<b>SIGNATURES</b>	
Laboratory Astrophysics	
188-44-57	W93-70201
<b>SILICATES</b>	
A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains	
152-12-40	W93-70143
Observations of the Moon, Mercury, and Primitive Asteroids	
196-41-03	W93-70217
<b>SILICON</b>	
Science Sensing (Remote)	
582-03-00	W93-70109
Surface Systems	
583-02-00	W93-70117
Micro Weather Stations for Mars	
157-04-80	W93-70174
Band Structure Engineering on Silicon CCDs for Enhanced UV Response	
188-41-24	W93-70188
<b>SIMULATION</b>	
Flight Systems Research and Technology	
505-68-00	W93-70014
Materials and Structures Research and Technology	
506-43-00	W93-70077
Space Flight Research and Technology	
506-48-00	W93-70079
Behavior, Performance and Human Factors	
199-06-12	W93-70231
Global Assessment of Active Volcanism	
428-81-96	W93-70270
Chemical Evolution of Interstellar Ices: The Connection with Primitive Solar System Materials	
452-33-93	W93-70306
Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption	
465-44-06	W93-70415
Two-Dimensional Stratospheric Chemical Model - Radiation	
579-23-01	W93-70451
Communications and Telemetry	
310-20-37	W93-70535
<b>SIMULATORS</b>	
Earth-Orbiting Platforms	
585-03-00	W93-70124
Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment	
462-32-03	W93-70341
<b>SINGLE CRYSTALS</b>	
Electronic Materials	
674-21-08	W93-70506

**SIS (SUPERCONDUCTORS)**

Science Sensing (Remote)	
582-03-00	W93-70112
Submillimeter Astronomy	
188-44-23	W93-70194
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar	
188-44-24	W93-70197
<b>SIZE SELECTION</b>	
Planetary Data System	
155-20-00	W93-70165
<b>SIZE DISTRIBUTION</b>	
Infrared Studies of Planetary Debris Around Young Main Sequence Stars	
452-11-93	W93-70301
CO2 Lidar Backscatter Experiment	
460-21-00	W93-70309
Validations of Passive Microwave Snow Water Equivalent Algorithm	
461-13-00	W93-70319
Heterogeneous Scene Models	
462-61-03	W93-70347
Satellite Observations of Volcanic Aerosols	
465-44-00	W93-70410
<b>SKY SURVEYS (ASTRONOMY)</b>	
Deep Optical/UV Imaging of Quasars Below the Lyman Limit	
188-41-21	W93-70183
Infrared Studies of Planetary Debris Around Young Main Sequence Stars	
452-11-93	W93-70301
<b>SMOKE</b>	
A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains	
152-12-40	W93-70143
<b>SNOW</b>	
Validations of Passive Microwave Snow Water Equivalent Algorithm	
461-13-00	W93-70319
Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR	
578-35-04	W93-70440
<b>SNOW COVER</b>	
Validations of Passive Microwave Snow Water Equivalent Algorithm	
461-13-00	W93-70319
<b>SODIUM</b>	
Observations of the Moon, Mercury, and Primitive Asteroids	
196-41-03	W93-70217
<b>SODIUM SULFUR BATTERIES</b>	
In-Space Technology Experiments	
506-74-00	W93-70103
<b>SOFIA (AIRBORNE OBSERVATORY)</b>	
Stratospheric Observatory for Infrared Astronomy (SOFIA)	
188-78-60	W93-70216
Two-Phase Nebulae	
452-22-93	W93-70304
<b>SOFTWARE ENGINEERING</b>	
Computational Aerosciences	
509-10-00	W93-70028
Computational/Aeroscience	
509-10-00	W93-70031
Earth and Space Sciences	
509-20-00	W93-70033
Earth and Space Sciences	
509-20-00	W93-70034
Information and Controls Research and Technology	
506-59-00	W93-70090
Information and Controls Research and Technology	
506-59-00	W93-70091
Automation and Robotics	
586-02-00	W93-70132
Software Engineering Technology	
310-10-23	W93-70527
Flight Dynamics Technology	
310-10-26	W93-70528
GPS-Based DSN Calibration System	
310-10-61	W93-70530
Space Systems and Navigation Technology	
310-10-63	W93-70532
Networks Communication Technology	
310-20-38	W93-70536
Mission Operations Technology	
310-40-45	W93-70546
Advanced Environments for Software and System Development	
310-40-49	W93-70549
<b>SOFTWARE REUSE</b>	
Earth and Space Sciences	
509-20-00	W93-70034
Automation and Robotics	
586-02-00	W93-70130

**SOFTWARE TOOLS**

Information and Controls Research and Technology	
506-59-00	W93-70088
Information and Controls Research and Technology	
506-59-00	W93-70091
Human Support Research and Technology	
506-71-00	W93-70095
Theory and Modeling: Infrared, Submillimeter, and Radio	
188-44-53	W93-70200
Project to Interface Modeling: EOSDIS Activities	
428-81-72	W93-70267
Geophysical Analysis and Modeling of LLR Data	
579-36-09	W93-70461
Data Interchange Standards	
656-61-03	W93-70479
PDS: Data Distribution and Archive Technology	
656-61-06	W93-70481
NSSDC Astrophysics Data Systems Support	
656-61-17	W93-70484
Image Animation Laboratory for Science Visualization	
656-65-04	W93-70488
Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data	
656-65-22	W93-70493
Construction of an Advanced Software Tool for Planetary Atmospheric Modeling	
656-65-24	W93-70494
A Distributed Analysis and Visualization System for Model and Observational Data	
656-65-27	W93-70497
<b>SOIL MAPPING</b>	
Synthetic Aperture Microwave Radiometer	
462-26-01	W93-70338
<b>SOIL MOISTURE</b>	
Hydrologic Processes, Field Study	
461-10-00	W93-70318
Measuring Soil Moisture With Imaging Radar	
461-13-00	W93-70320
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions	
461-13-01	W93-70321
Synthetic Aperture Microwave Radiometer	
462-26-01	W93-70338
Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment	
462-32-03	W93-70341
ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)	
462-32-61	W93-70342
Soil Moisture from SAR	
462-62-05	W93-70349
ERS-1 Radar Permafrost Penetration	
465-41-01	W93-70407
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions	
579-42-02	W93-70468
Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling	
579-42-13	W93-70471
<b>SOIL SCIENCE</b>	
Forest/Climate Interactions	
462-21-00	W93-70337
ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)	
462-32-61	W93-70342
Carbon Mass Balance During Soil Evolution Along Climate Gradients	
465-45-01	W93-70416
<b>SOILS</b>	
Desert Mesoscale/PBL	
461-13-02	W93-70322
ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)	
462-32-61	W93-70342
ERS-1 Radar Permafrost Penetration	
465-41-01	W93-70407
Carbon Mass Balance During Soil Evolution Along Climate Gradients	
465-45-01	W93-70416
ASF SAR Interferometry	
665-35-01	W93-70500
<b>SOLAR ACTIVITY</b>	
Solar Physics Studies	
170-38-53	W93-70181
<b>SOLAR ACTIVITY EFFECTS</b>	
Proposal for a High-Energy Imaging Device (HEIDI) on a Balloon	
879-11-48	W93-70523
<b>SOLAR ARRAYS</b>	
Space Energy Conversion Research and Technology	
506-41-00	W93-70067

- Space Flight Research and Technology  
506-48-00 W93-70078
- Space Flight Research and Technology  
506-48-00 W93-70080
- SOLAR ATMOSPHERE**  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521  
Sounding Rocket Experiments  
879-11-38 W93-70522
- SOLAR CELLS**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067  
Earth-Orbiting Platforms  
585-03-00 W93-70124
- SOLAR COLLECTORS**  
Earth-Orbiting Platforms  
585-03-00 W93-70124
- SOLAR CORONA**  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521  
Sounding Rocket Experiments  
879-11-38 W93-70522
- SOLAR CORPUSCULAR RADIATION**  
Radiation Health  
199-04-11 W93-70226
- SOLAR ECLIPSES**  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521
- SOLAR ELECTRONS**  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521
- SOLAR ENERGY**  
Dynamics of Planetary Atmospheres  
154-20-80 W93-70153
- SOLAR ENERGY CONVERSION**  
Materials and Structures Research and Technology  
506-43-00 W93-70077
- SOLAR FLARES**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180  
Radiation Health  
199-04-11 W93-70226  
Sounding Rocket Experiments  
879-11-38 W93-70522  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523
- SOLAR GENERATORS**  
Earth-Orbiting Platforms  
585-03-00 W93-70124
- SOLAR HEATING**  
Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451
- SOLAR MAGNETIC FIELD**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180
- SOLAR MAXIMUM MISSION**  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523
- SOLAR MESOSPHERE EXPLORER**  
Solar Physics Studies  
170-38-53 W93-70181
- SOLAR OBSERVATORIES**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205
- SOLAR ORBITS**  
Sounding Rocket Experiments  
879-11-38 W93-70522
- SOLAR OSCILLATIONS**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179
- SOLAR PHYSICS**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180  
Solar Physics Studies  
170-38-53 W93-70181
- Space Physics Theory Program  
431-06-00 W93-70291  
Solar Wind-Magnetosphere-Ionosphere Coupling,  
Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292  
Interdisciplinary ATD Studies  
433-04-00 W93-70295  
Space Physics Program Support/Details  
433-90-00 W93-70297  
High Energy Astrophysics International Programs  
440-62-59 W93-70299
- SOLAR PLANETARY INTERACTIONS**  
Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157
- SOLAR POSITION**  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217
- SOLAR PROBES**  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Solar Probe ATD  
433-06-00 W93-70296
- SOLAR PROPULSION**  
System Analysis  
506-49-00 W93-70083
- SOLAR RADIATION**  
Mars 3-D Global Circulation Model  
154-95-80 W93-70161  
Solar Physics Studies  
170-38-53 W93-70181  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Sounding Rocket Experiments  
879-11-38 W93-70522
- SOLAR SPECTRA**  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
Neptune Data Analysis Program  
889-59-00 W93-70526
- SOLAR SPECTROMETERS**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177
- SOLAR STORMS**  
Radiation Health  
199-04-11 W93-70226
- SOLAR SYSTEM**  
Space Flight Research and Technology  
506-48-00 W93-70078  
Systems Analysis  
506-49-00 W93-70085  
Solar System Studies  
151-01-60 W93-70138  
Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials - Carbonaceous Meteorites and  
Cometary Ice Analogs  
152-13-60 W93-70145  
Planetary Materials: Geochronology  
152-14-40 W93-70146  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Mars Data Analysis  
155-20-00 W93-70164  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Volatiles in the Solar System  
196-41-67 W93-70221  
Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245  
Solar System Exploration  
199-52-52 W93-70249  
Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253  
Planet-Forming Disks  
452-21-93 W93-70302  
Two-Phase Nebulae  
452-22-93 W93-70304  
Origins of Solar Systems  
452-23-94 W93-70305  
Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306
- Management Support: Origins of Solar Systems  
Research Program  
452-89-91 W93-70307  
Solar System Visualization (SSV): Scientific Tools for  
NASA/JPL Image Archives  
656-65-06 W93-70490  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523
- SOLAR SYSTEM EVOLUTION**  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Theory and Modeling: Infrared, Submillimeter, and  
Radio  
188-44-53 W93-70200
- SOLAR VELOCITY**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179
- SOLAR WIND**  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178  
Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180  
Imaging Studies of Comets  
196-41-52 W93-70219  
Solar Wind-Magnetosphere-Ionosphere Coupling,  
Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521  
Sounding Rocket Experiments  
879-11-38 W93-70522  
Neptune Data Analysis  
889-59-00 W93-70524
- SOLID LUBRICANTS**  
Materials and Structures Research and Technology  
506-43-00 W93-70073
- SOLID STATE**  
Science Sensing (Remote)  
582-03-00 W93-70110
- SOLID STATE DEVICES**  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Space Communications Research and Technology  
506-72-00 W93-70096  
Science Sensing (Remote)  
582-03-00 W93-70112  
Science Sensing (Remote)  
582-03-00 W93-70113  
Surface Systems  
583-02-00 W93-70117  
Wind Measurement Assessment  
460-28-41 W93-70314
- SOLID STATE LASERS**  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172  
Advanced Magnetometer  
465-31-01 W93-70404
- SOLID WASTES**  
Human Support Research and Technology  
506-71-00 W93-70093
- SOLIDIFICATION**  
Electronic Materials  
674-21-08 W93-70506  
Fluid Physics  
674-24-08 W93-70512  
Metals and Alloys  
674-25-05 W93-70513  
Metals and Alloys  
674-25-08 W93-70514
- SONAR**  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501
- SONIC BOOMS**  
Atmospheric Effects  
537-01-00 W93-70049  
Emissions and Source Noise  
537-02-00 W93-70053  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Community Noise and Sonic Boom  
537-03-00 W93-70057
- SOUNDING**  
Meteorological Parameters Extraction  
578-12-20 W93-70427

**SOUNDING ROCKETS**

Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298  
Sounding Rocket Experiments  
879-11-38 W93-70522

**SOUTH AMERICA**

Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389

**SOUTHERN HEMISPHERE**

Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
Atmospheric Backscatter Experiment  
460-22-53 W93-70313  
Microwave Temperature Profiler  
464-14-20 W93-70374

**SOVIET SPACECRAFT**

High Energy Astrophysics International Programs  
440-62-59 W93-70299

**SPACE COMMERCIALIZATION**

Earth-to-Orbit Transportation  
584-03-00 W93-70120  
Electronic Materials  
674-21-05 W93-70505  
Combustion Science  
674-22-05 W93-70507  
Fluid Physics  
674-24-05 W93-70511

**SPACE COMMUNICATION**

Space Communications Research and Technology  
506-72-00 W93-70096  
Space Communications Research and Technology  
506-72-00 W93-70097  
Space Communications Research and Technology  
506-72-00 W93-70099  
Goldstone DOSE Support  
465-28-02 W93-70403  
Optical Communications  
310-20-35 W93-70533  
Optical Communications Technology Development  
310-20-67 W93-70541  
Communication Systems Research  
310-30-71 W93-70544

**SPACE DEBRIS**

Materials and Structures Research and Technology  
506-43-00 W93-70077  
Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301

**SPACE EXPLORATION**

Propulsion Research and Technology  
506-42-00 W93-70070  
Materials and Structures Research and Technology  
506-43-00 W93-70076  
Systems Analysis  
506-49-00 W93-70085  
In-Space Technology Experiments  
506-74-00 W93-70103  
Space Transportation  
584-04-00 W93-70122  
Mars Data Analysis  
155-20-00 W93-70164  
Planetary Data System  
155-20-00 W93-70165  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166  
Mars 94 Gravity  
155-20-03 W93-70167  
Planetary Instrument Definition and Development  
157-03-50 W93-70169  
Telepresence for Planetary Exploration  
186-06-01 W93-70182  
Solar System Exploration  
199-52-52 W93-70249  
Exploration Exobiology  
199-52-82 W93-70251  
Controlled Ecological Life Support Systems (CELSS)  
Project  
199-61-11 W93-70253  
Solar System Visualization (SSV): Scientific Tools for  
NASA/JPL Image Archives  
656-65-06 W93-70490  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498

**SPACE FLIGHT**

Behavior and Performance Research  
199-06-11 W93-70230  
Flight Research  
199-40-62 W93-70243  
Ocean Color Data System  
428-82-06 W93-70272

**SPACE FLIGHT STRESS**

Longitudinal Studies (Medical Operations Longitudinal  
Studies)  
199-02-31 W93-70224  
Space Human Factors Behavior and Performance  
199-06-11 W93-70229

**SPACE HABITATS**

Human Support Research and Technology  
506-71-00 W93-70093  
Space Human Factors Behavior and Performance  
199-06-11 W93-70229

**SPACE INFRARED TELESCOPE FACILITY**

Infrared/Radio Research  
188-44-21 W93-70193  
Laboratory Astrophysics  
188-44-57 W93-70203  
IR Astronomy ATD/Cryo Optical Testing and Science  
Support Activities  
188-78-44 W93-70214  
Two-Phase Nebulae  
452-22-93 W93-70304

**SPACE LABORATORIES**

Flight Research  
199-40-72 W93-70244

**SPACE MANUFACTURING**

Electronic Materials  
674-21-05 W93-70505  
Biotechnology  
674-23-08 W93-70509

**SPACE MISSIONS**

Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Propulsion Research and Technology  
506-42-00 W93-70068  
Systems Analysis  
506-49-00 W93-70084  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166  
Planetary Instrument Development Program/Planetary  
Astronomy High Temperature Superconductor  
Bolometers  
157-05-50 W93-70175  
Optical Stellar Interferometry  
188-41-21 W93-70184  
Infrared/Radio Research  
188-44-21 W93-70193  
Integral Mission Definition Study  
188-78-01 W93-70211  
Volatiles in the Solar System  
196-41-67 W93-70221  
Space Radiation Effects and Protection (Environmental  
Health)  
199-04-00 W93-70225  
Behavior and Performance Research  
199-06-11 W93-70230  
Interdisciplinary ATD Studies  
433-04-00 W93-70295  
Space Physics Data System  
656-61-18 W93-70485  
Data Storage Technology  
310-40-48 W93-70548

**SPACE NAVIGATION**

Information and Controls Research and Technology  
506-59-00 W93-70092  
Astrometric Development Technology  
310-10-60 W93-70529  
Space Systems and Navigation Technology  
310-10-63 W93-70532

**SPACE OBSERVATIONS (FROM EARTH)**

UV Astronomy and Data Systems  
188-41-51 W93-70189  
Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195  
Imaging Studies of Comets  
196-41-52 W93-70219

**SPACE PLASMAS**

Space Flight Research and Technology  
506-48-00 W93-70078  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178  
Space Physics Theory Program  
431-06-00 W93-70291  
Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298

**SPACE PLATFORMS**

Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Systems Analysis  
506-49-00 W93-70084

Human Support Research and Technology  
506-71-00 W93-70093  
In-Space Experiments  
506-74-00 W93-70102  
Science Sensing (Remote)  
582-03-00 W93-70111  
Global Hydrologic Cycle  
429-81-16 W93-70278  
Validation of Volcanic Plume Models with Remote  
Sensing  
465-44-04 W93-70413  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Data Analysis  
578-10-00 W93-70421  
Climate Modeling with Emphasis on Aerosols and  
Clouds  
578-11-01 W93-70422  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Modeling  
578-40-00 W93-70441  
Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537

**SPACE POWER REACTORS**

Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Surface Systems  
583-02-00 W93-70116  
Surface Systems  
583-02-00 W93-70117

**SPACE PROCESSING**

Information and Communications  
586-03-00 W93-70135  
Electronic Materials  
674-21-05 W93-70505  
Biotechnology  
674-23-08 W93-70509  
Metals and Alloys  
674-25-05 W93-70513  
Glasses and Ceramics  
674-26-05 W93-70515  
Glasses and Ceramics  
674-26-08 W93-70516  
Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517  
Ground Experiment Operations  
674-28-05 W93-70518

**SPACE PROGRAMS**

University Space Engineering Research  
506-50-00 W93-70086

**SPACE SHUTTLE MAIN ENGINE**

Advanced Composite Materials Technology  
510-02-00 W93-70037

**SPACE SHUTTLE ORBITERS**

Materials and Structures Research and Technology  
506-43-00 W93-70071  
Space Flight Research and Technology  
506-48-00 W93-70079  
Space Flight Research and Technology  
506-48-00 W93-70080  
In-Space Experiments  
506-74-00 W93-70105  
Automation and Robotics  
586-02-00 W93-70127

**SPACE SHUTTLE PAYLOADS**

Automation and Robotics  
586-02-00 W93-70133

**SPACE SHUTTLES**

Space Flight Research and Technology  
506-48-00 W93-70081  
Information and Controls Research and Technology  
506-59-00 W93-70092  
In-Space Experiments  
506-74-00 W93-70102  
Earth-to-Orbit Transportation  
584-03-00 W93-70118  
Radiation Health  
199-04-11 W93-70226

**SPACE SIMULATORS**

Ground Experiment Operations  
674-28-05 W93-70518

**SPACE STATION FREEDOM**

Information and Controls Research and Technology  
506-59-00 W93-70089  
Information and Controls Research and Technology  
506-59-00 W93-70092  
Earth-Orbiting Platforms  
585-03-00 W93-70124  
Automation and Robotics  
586-02-00 W93-70127  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70129  
Automation and Robotics  
586-02-00 W93-70132

Clinical Medicine Technology Watch 199-02-31	W93-70223	Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions 370-03-00	W93-70255	<b>SPACECRAFT PERFORMANCE</b> Materials and Structures Research and Technology 506-43-00	W93-70074
Space Radiation Effects and Protection (Environmental Health) 199-04-00	W93-70225	Biotechnology 674-23-08	W93-70509	<b>SPACECRAFT POWER SUPPLIES</b> Space Energy Conversion Research and Technology 506-41-00	W93-70064
Flight Dynamics Technology 310-10-26	W93-70528	Fluid Physics 674-24-00	W93-70510	Space Energy Conversion Research and Technology 506-41-00	W93-70065
<b>SPACE STATION PAYLOADS</b> Exobiology Intact Capture Technology Development 199-52-54	W93-70250	Fluid Physics 674-24-05	W93-70511	Space Energy Conversion Research and Technology 506-41-00	W93-70067
<b>SPACE STATIONS</b> Materials and Structures Research and Technology 506-43-00	W93-70076	Glasses and Ceramics 674-26-08	W93-70516	Materials and Structures Research and Technology 506-43-00	W93-70073
Systems Analysis 506-49-00	W93-70084	Ground Experiment Operations 674-28-08	W93-70519	Space Flight Research and Technology 506-48-00	W93-70078
Information and Controls Research and Technology 506-59-00	W93-70092	<b>SPACEBORNE TELESCOPES</b> Astrometric Imaging Telescope 157-03-70	W93-70171	In-Space Technology Experiments 506-74-00	W93-70103
In-Space Experiments 506-74-00	W93-70102	<b>SPACECRAFT COMMUNICATION</b> Radio Systems Development 310-20-66	W93-70540	Surface Systems 583-02-00	W93-70117
In-Space Technology Experiments 506-74-00	W93-70106	<b>SPACECRAFT COMPONENTS</b> Flight Research 199-40-62	W93-70243	Earth-Orbiting Platforms 585-03-00	W93-70124
Automation and Robotics 586-02-00	W93-70131	<b>SPACECRAFT CONFIGURATIONS</b> Solar Probe ATD 433-06-00	W93-70296	Automation and Robotics 586-02-00	W93-70128
Information and Communications 586-03-00	W93-70135	<b>SPACECRAFT CONSTRUCTION MATERIALS</b> Materials and Structures Research and Technology 505-63-00	W93-70007	<b>SPACECRAFT PROPULSION</b> Materials and Structures Research and Technology 505-63-00	W93-70008
Radiation Health 199-04-11	W93-70226	Materials and Structures Research and Technology 506-43-00	W93-70073	Propulsion Research and Technology 506-42-00	W93-70068
Environmental Health 199-04-11	W93-70227	Materials and Structures Research and Technology 506-43-00	W93-70074	Propulsion Research and Technology 506-42-00	W93-70070
Solar System Exploration 199-52-52	W93-70249	Materials and Structures Research and Technology 506-43-00	W93-70076	Materials and Structures Research and Technology 506-43-00	W93-70073
Combustion Science 674-22-05	W93-70507	Materials and Structures Research and Technology 506-43-00	W93-70077	System Analysis 506-49-00	W93-70083
Biotechnology Research 674-23-01	W93-70508	Solar Probe ATD 433-06-00	W93-70296	In-Space Technology Experiments 506-74-00	W93-70103
Advanced Telemetry Processing Technology 310-40-51	W93-70550	<b>SPACECRAFT CONTROL</b> Materials and Structures Research and Technology 506-43-00	W93-70074	<b>SPACECRAFT SHIELDING</b> Solar Probe ATD 433-06-00	W93-70296
<b>SPACE SUITS</b> Human Support Research and Technology 506-71-00	W93-70093	Information and Controls Research and Technology 506-59-00	W93-70089	<b>SPACECRAFT STABILITY</b> Information and Controls Research and Technology 506-59-00	W93-70092
<b>SPACE TRANSPORTATION</b> Propulsion Research and Technology 506-42-00	W93-70068	In-Space Technology Experiments 506-74-00	W93-70104	<b>SPACECRAFT STRUCTURES</b> Materials and Structures Research and Technology 506-43-00	W93-70072
Systems Analysis 506-49-00	W93-70084	Automation and Robotics 586-02-00	W93-70127	Materials and Structures Research and Technology 506-43-00	W93-70075
Earth-to-Orbit Transportation 584-03-00	W93-70121	Information and Communications 586-02-00	W93-70134	In-Space Technology Experiments 506-74-00	W93-70104
Space Transportation 584-04-00	W93-70122	<b>SPACECRAFT DESIGN</b> Materials and Structures Research and Technology 506-43-00	W93-70072	<b>SPACECRAFT TEMPERATURE</b> In-Space Technology Experiments 506-74-00	W93-70107
Space Transportation 584-04-00	W93-70123	Materials and Structures Research and Technology 506-43-00	W93-70074	<b>SPACECRAFT TRACKING</b> GPS-Based DSN Calibration System 310-10-61	W93-70530
<b>SPACE TRANSPORTATION SYSTEM</b> Space Energy Conversion Research and Technology 506-41-00	W93-70064	Space Flight Research and Technology 506-48-00	W93-70081	<b>SPACECREWS</b> In-Space Experiments 506-74-00	W93-70102
Materials and Structures Research and Technology 506-43-00	W93-70074	System Analysis 506-49-00	W93-70083	Clinical Medicine Technology Watch 199-02-31	W93-70223
Space Flight Research and Technology 506-48-00	W93-70079	University Space Engineering Research 506-50-00	W93-70086	Behavior and Performance Research 199-06-11	W93-70230
Information and Controls Research and Technology 506-59-00	W93-70089	Interdisciplinary ATD Studies 433-04-00	W93-70295	Behavior, Performance and Human Factors 199-06-12	W93-70231
In-Space Technology Experiments 506-74-00	W93-70106	Solar Probe ATD 433-06-00	W93-70296	General Biomedical: Center and Headquarters Support 199-08-11	W93-70232
Flight Dynamics Technology 310-10-26	W93-70528	<b>SPACECRAFT ENVIRONMENTS</b> Space Flight Research and Technology 506-48-00	W93-70079	Regulatory Physiology (Biomedical) 199-18-12	W93-70235
Advanced Space Systems for Users of NASA Networks 310-20-46	W93-70537	Environmental Health 199-04-11	W93-70227	<b>SPAIN</b> Measuring Soil Moisture With Imaging Radar 461-13-00	W93-70320
<b>SPACEBORNE ASTRONOMY</b> Optical Technology for Space Astronomy 188-41-23	W93-70186	Behavior, Performance and Human Factors 199-06-12	W93-70231	ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA) 462-32-61	W93-70342
<b>SPACEBORNE EXPERIMENTS</b> Space Flight Research and Technology 506-48-00	W93-70078	<b>SPACECRAFT EQUIPMENT</b> Flight Research 199-40-72	W93-70244	<b>SPARK CHAMBERS</b> Gamma Ray Astronomy 188-46-57	W93-70207
Space Flight Research and Technology 506-48-00	W93-70080	<b>SPACECRAFT GLOW</b> Space Flight Research and Technology 506-48-00	W93-70080	<b>SPATIAL DISTRIBUTION</b> Studies of Volcanic SO <sub>2</sub> 428-81-99	W93-70271
Space Flight Research and Technology 506-48-00	W93-70081	In-Space Technology Experiments 506-74-00	W93-70107	Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment 462-32-03	W93-70341
In-Space Technology Experiments 506-74-00	W93-70104	<b>SPACECRAFT INSTRUMENTS</b> Space Flight Research and Technology 506-48-00	W93-70080	Satellite Radar for Forest Structure 462-41-61	W93-70343
In-Space Experiments 506-74-00	W93-70105	Integral Mission Definition Study 188-78-01	W93-70211	Airborne IR Spectrometry 464-12-00	W93-70367
In-Space Technology Experiments 506-74-00	W93-70107	<b>SPACECRAFT LAUNCHING</b> Propulsion Research and Technology 506-42-00	W93-70068	Satellite Observations of Volcanic Aerosols 465-44-00	W93-70410
Cosmic and Heliospheric Physics 170-10-10	W93-70176	Information and Controls Research and Technology 506-59-00	W93-70089	Sea Ice Motion in the Pacific Sector of the Arctic 578-35-01	W93-70438
High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies 188-46-01	W93-70205	Automation and Robotics 586-02-00	W93-70129	ERS-1 Studies of Forest Ecosystems 579-41-08	W93-70466
Cardiopulmonary Physiology 199-14-12	W93-70233	<b>SPACECRAFT MODELS</b> Project to Interface Modeling 429-81-72	W93-70283	Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions 579-43-00	W93-70472
Flight Research 199-40-62	W93-70243	JPL Oceanography Group Common Computer System 578-22-27	W93-70434		
Flight Research 199-40-72	W93-70244				

**SPATIAL RESOLUTION**

Ground-Based Support of Solar Physics  
170-38-52 W93-70179  
Development of UV Photon Counting Geometrically  
Stable Array Detector - Multi-Anode Microchannel Array  
(MAMA)  
188-41-24 W93-70187  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Airborne ESTAR  
461-38-01 W93-70327  
AVIRIS Operations  
463-75-63 W93-70364  
Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402  
AVIRIS Operations  
465-65-01 W93-70417  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488  
ASF SAR Interferometry  
665-35-01 W93-70500

**SPECIFICATIONS**  
Surface Systems  
583-02-00 W93-70117

**SPECTRA**  
Optical Technology for Space Astronomy  
188-41-23 W93-70186  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301  
AVIRIS Operations  
465-65-01 W93-70417  
Neptune Data Analysis Program  
889-59-00 W93-70526

**SPECTRAL BANDS**  
Optical Technology for Space Astronomy  
188-41-23 W93-70186  
The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons  
399-50-00 W93-70261  
IR Remote Sensing of SST  
460-21-28 W93-70310  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425

**SPECTRAL LINE WIDTH**  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

**SPECTRAL REFLECTANCE**  
Heterogeneous Scene Models  
462-61-03 W93-70347  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468

**SPECTRAL RESOLUTION**  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
Submillimeter Astronomy  
188-44-23 W93-70194

**SPECTROGRAPHS**  
Development of UV Photon Counting Geometrically  
Stable Array Detector - Multi-Anode Microchannel Array  
(MAMA)  
188-41-24 W93-70187

**SPECTROHELIOGRAPHS**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179

**SPECTROMETERS**  
Information and Controls Research and Technology  
506-59-00 W93-70090  
Science Sensing (Remote)  
582-03-00 W93-70111  
Information and Communications  
586-03-00 W93-70137  
Mars Atmosphere Dust Opacity  
155-04-00 W93-70163  
Laboratory Astrophysics  
188-44-57 W93-70203  
Ground-Based Infrared Astronomy  
196-41-50 W93-70218

Advanced Infrared Astronomy  
196-41-54 W93-70220  
The Development of a Mid-Infrared Spectrometer for  
the Infrared Telescope in Space  
440-63-44 W93-70300  
Thermal Infrared Science Support  
462-75-74 W93-70352  
Airborne IR Spectrometry  
464-12-00 W93-70367  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381  
Laser Laboratory Spectroscopy  
464-23-09 W93-70382  
Measurement of Volcanic Gases  
465-44-05 W93-70414  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523

**SPECTRORADIOMETERS**  
Remote Measurement of the Gain of Satellite  
Radiometers: The NASA Aircraft Satellite Instrument  
Calibration (NASIC) Project  
428-82-18 W93-70274  
Heterogeneous Scene Models  
462-61-03 W93-70347

**SPECTROSCOPIC ANALYSIS**  
Integral Mission Definition Study  
188-78-01 W93-70211  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386

**SPECTROSCOPY**  
Deep Optical/UV Imaging of Quasars Below the Lyman  
Limit  
188-41-21 W93-70183  
UV Astronomy and Data Systems  
188-41-51 W93-70189  
Photoprocesses/Spectroscopies of Astrophysical  
Molecules and Radicals  
188-41-57 W93-70190  
Properties of Interstellar PAH's  
188-44-57 W93-70202  
Gamma-Ray Spectroscopy  
188-46-58 W93-70208  
Integral Mission Definition Study  
188-78-01 W93-70211  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217  
The Nature of Interstellar Dust, Ices and Polycyclic  
Aromatic Hydrocarbons  
399-50-00 W93-70261  
Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301  
Chemical Evolution of Interstellar Ices: The Connection  
with Primitive Solar System Materials  
452-33-93 W93-70306  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

**SPECTRUM ANALYSIS**  
Laboratory Astrophysics  
188-44-57 W93-70201  
Properties of Interstellar PAH's  
188-44-57 W93-70202  
Laboratory Astrophysics  
188-44-57 W93-70203  
Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204  
Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346  
Airborne IR Spectrometry  
464-12-00 W93-70367  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
Laser Laboratory Spectroscopy  
464-23-09 W93-70382

Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383  
Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402

**SPHERICAL TANKS**  
In-Space Experiments  
506-74-00 W93-70105

**SPHINX**  
Magnetospheric Physics - Particles and Particle/Field  
Interaction  
170-10-10 W93-70178

**SPIN RESONANCE**  
Space Radiation  
199-04-14 W93-70228

**SPINE FUNCTIONS**  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457

**SPREADING**  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408

**SR-71 AIRCRAFT**  
Flight Systems Research and Technology  
505-68-00 W93-70013

**STABILITY**  
Aerodynamics Research and Technology  
505-59-00 W93-70003  
Climate Stability: The Role of the Hydrological Cycle  
and the Thermohaline Circulation  
578-31-14 W93-70436

**STANDARDS**  
Lidar Target Calibration Facility  
460-22-52 W93-70312  
Data Interchange Standards  
656-61-03 W93-70479  
Software Engineering Technology  
310-10-23 W93-70527

**STAR FORMATION**  
Submillimeter Astronomy  
188-44-23 W93-70194  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
Center for Star Formation Studies  
399-20-01 W93-70260  
Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301

**STARS**  
Optical Stellar Interferometry  
188-41-21 W93-70184

**STATISTICAL ANALYSIS**  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303

**STATISTICAL DISTRIBUTIONS**  
Remote Sensing of Active and Recently Active Volcanic  
Features  
465-44-01 W93-70411

**STEADY FLOW**  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

**STEERABLE ANTENNAS**  
Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537

**STELLAR ATMOSPHERES**  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191

**STELLAR ENVELOPES**  
Submillimeter Astronomy  
188-44-23 W93-70194  
Laboratory Astrophysics  
188-44-57 W93-70203  
Center for Star Formation Studies  
399-20-01 W93-70260  
Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301  
Origins of Solar Systems  
452-23-94 W93-70305

**STELLAR EVOLUTION**  
Solar System Studies  
151-01-60 W93-70138  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Cosmic and Heliospheric Physics  
170-10-10 W93-70176

## SUBJECT INDEX

Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199

Origins of Solar Systems  
452-23-94 W93-70305

**STELLAR LUMINOSITY**  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

**STELLAR MASS**  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

Center for Star Formation Studies  
399-20-01 W93-70260

**STELLAR MODELS**  
UV Astronomy and Data Systems  
188-41-51 W93-70189

Convective Transport in the Solar Nebula  
452-22-91 W93-70303

**STELLAR ROTATION**  
Simulations of Compact Radio Sources  
188-44-53 W93-70198

**STELLAR SPECTRA**  
Optical Interferometry in Space  
188-78-41 W93-70213

**STEPPIES**  
Validations of Passive Microwave Snow Water  
Equivalent Algorithm  
461-13-00 W93-70319

**STIMULATED EMISSION**  
Radio Systems Development  
310-20-66 W93-70540

**STIRLING CYCLE**  
Observatory Systems  
582-04-00 W93-70115

Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206

**STORAGE STABILITY**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067

**STORAGE TANKS**  
Materials and Structures Research and Technology  
506-43-00 W93-70071

Earth-to-Orbit Transportation  
584-03-00 W93-70120

**STORMS**  
Airborne Precipitation Radar  
461-51-16 W93-70332

Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341

**STOVL AIRCRAFT**  
Flight Systems Research and Technology  
505-68-00 W93-70014

High-Performance Flight Research  
533-02-00 W93-70041

**STRAIN DISTRIBUTION**  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389

GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391

**STRAIN GAGES**  
Materials and Structures Research and Technology  
505-63-00 W93-70006

**STRAIN MEASUREMENT**  
Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402

**STRAIN RATE**  
Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402

**STRATA**  
Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359

GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391

Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409

**STRATIFICATION**  
Spatial and Temporal Distribution of Biomass  
Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472

**STRATIGRAPHY**  
Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360

Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409

**STRATOCUMULUS CLOUDS**  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315

**STRATOSPHERE**  
Atmospheric Effects  
537-01-00 W93-70049

Atmospheric Effects  
537-01-00 W93-70050

Atmospheric Effects  
537-01-00 W93-70052

Emissions and Source Noise  
537-02-00 W93-70054

EOS IDS, EOSDIS Money  
428-81-36 W93-70266

EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280

Ozone Measurements  
464-11-05 W93-70365

Laser Diode Sensor  
464-11-07 W93-70366

Airborne IR Spectrometry  
464-12-00 W93-70367

IR Solar Absorption Spectra  
464-12-05 W93-70368

MM and Sub-MM Radiometry  
464-12-06 W93-70369

Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370

NDSC Differential Absorption Lidar  
464-13-15 W93-70371

NDSC Microwave Instrument Support  
464-13-22 W93-70372

Stratospheric Processes and Atmospheric Chemistry  
Studies  
464-14-00 W93-70373

Microwave Temperature Profiler  
464-14-20 W93-70374

Multi-Sensor Balloon Measurements  
464-16-01 W93-70375

Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376

Homogeneous and Heterogeneous Processes of  
Atmospheric Interest  
464-21-05 W93-70377

Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378

Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379

Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381

Laser Laboratory Spectroscopy  
464-23-09 W93-70382

Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384

Data Survey and Evaluation  
464-41-04 W93-70385

Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410

Volcanic Cloud Dispersion, Chemistry and Microphysics:  
An Analysis of the El Chichon Eruption  
465-44-06 W93-70415

Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450

Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451

Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

Climatological Stratospheric Modeling  
579-24-09 W93-70455

**STRATUS CLOUDS**  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315

Experimental Cloud Analysis Techniques  
578-12-01 W93-70424

**STRESS ANALYSIS**  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303

Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388

Dynamics of North American-Pacific Shear  
465-13-02 W93-70390

**STRESS DISTRIBUTION**  
Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388

## STRUCTURAL PROPERTIES (GEOLOGY)

GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391

**STRESS-STRAIN RELATIONSHIPS**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036

Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388

**STRUCTURAL ANALYSIS**  
Materials and Structures Research and Technology  
505-63-00 W93-70007

Materials and Structures Research and Technology  
505-63-00 W93-70009

Computational Aerosciences  
509-10-00 W93-70029

Advanced High Temperature Engine Materials  
510-01-00 W93-70036

Advanced Composite Materials Technology  
510-02-00 W93-70037

Advanced Composite Materials Technology  
510-02-00 W93-70038

Advanced Rotorcraft Technology  
532-06-00 W93-70040

Aging Aircraft  
538-02-00 W93-70061

**STRUCTURAL BASINS**  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic  
Resurfacing  
151-02-00 W93-70140

Foreign Visitor Support  
429-97-04 W93-70290

**STRUCTURAL DESIGN**  
Materials and Structures Research and Technology  
505-63-00 W93-70008

Materials and Structures Research and Technology  
505-63-00 W93-70009

Advanced Composite Materials Technology  
510-02-00 W93-70038

Advanced Rotorcraft Technology  
532-06-00 W93-70040

Materials and Structures Research and Technology  
506-43-00 W93-70072

**STRUCTURAL ENGINEERING**  
Materials and Structures Research and Technology  
505-63-00 W93-70006

Materials and Structures Research and Technology  
505-63-00 W93-70007

Materials and Structures Research and Technology  
505-63-00 W93-70008

Materials and Structures Research and Technology  
505-63-00 W93-70009

Materials and Structures Research and Technology  
506-43-00 W93-70071

Materials and Structures Research and Technology  
506-43-00 W93-70072

Materials and Structures Research and Technology  
506-43-00 W93-70073

Materials and Structures Research and Technology  
506-43-00 W93-70074

Materials and Structures Research and Technology  
506-43-00 W93-70075

Materials and Structures Research and Technology  
506-43-00 W93-70076

Materials and Structures Research and Technology  
506-43-00 W93-70077

Earth-Orbiting Platforms  
585-03-00 W93-70126

Simulations of Compact Radio Sources  
188-44-53 W93-70198

**STRUCTURAL FAILURE**  
Aging Aircraft  
538-02-00 W93-70061

Materials and Structures Research and Technology  
506-43-00 W93-70072

Information and Controls Research and Technology  
506-59-00 W93-70088

**STRUCTURAL PROPERTIES (GEOLOGY)**  
Dynamics of North American-Pacific Shear  
465-13-02 W93-70390

GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391

Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395

Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408

Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409

Topography from SEASAT and GEOSAT Overland  
Altimetry  
579-42-03 W93-70469

**STRUCTURAL VIBRATION**

In-Space Technology Experiments  
506-74-00 W93-70104

**STRUCTURAL WEIGHT**

Hypersonic Research and Technology  
505-70-00 W93-70022

**STUDENTS**

Hypersonic Training and Research  
505-70-00 W93-70021  
Interdisciplinary Technology  
505-90-00 W93-70027  
Graduate Fellowships  
578-97-16 W93-70447  
Windows on Global Change  
665-82-03 W93-70503

**SUBDUCTION (GEOLOGY)**

Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389

**SUBMILLIMETER WAVES**

Science Sensing (Remote)  
582-03-00 W93-70111  
Science Sensing (Remote)  
582-03-00 W93-70112  
Observatory Systems  
582-04-00 W93-70114  
Observatory Systems  
582-04-00 W93-70115  
Space Data Systems  
586-03-00 W93-70136  
Infrared/Radio Research  
188-44-21 W93-70193  
Submillimeter Astronomy  
188-44-23 W93-70194  
Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Theory and Modeling: Infrared, Submillimeter, and  
Radio  
188-44-53 W93-70200  
Laboratory Astrophysics  
188-44-57 W93-70201  
MM and Sub-MM Radiometry  
464-12-06 W93-70369

**SUBSONIC AIRCRAFT**

High-Performance Flight Research  
533-02-00 W93-70043

**SUBSONIC SPEED**

Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Advanced Rotorcraft Technology  
532-06-00 W93-70039

**SUBSTRATES**

Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188

**SULFUR**

Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245  
Measurement of Volcanic Gases  
465-44-05 W93-70414

**SULFUR DIOXIDES**

Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Studies of Volcanic SO<sub>2</sub>  
428-81-99 W93-70271  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289

**SUMMER**

ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

**SUN**

Theory, Laboratory and Data Analysis for Solar  
Physics  
170-38-53 W93-70180

**SUNSPOTS**

Modeling of the Main Magnetic Field  
579-31-02 W93-70457

**SUPERCOMPUTERS**

NAS Operations  
536-02-00 W93-70048  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
A 4D Data Assimilation for EOS Computer Support  
428-81-04 W93-70262

A Distributed Analysis and Visualization System for  
Model and Observational Data  
656-65-27 W93-70497

**SUPERCONDUCTING FILMS**

Information and Controls Research and Technology  
506-59-00 W93-70090

**SUPERCONDUCTIVITY**

Science Sensing (Remote)  
582-03-00 W93-70112  
Frequency and Timing Research  
310-10-62 W93-70531

**SUPERCONDUCTORS**

Information and Controls Research and Technology  
506-59-00 W93-70090

**SUPERHIGH FREQUENCIES**

Space Communications Research and Technology  
506-72-00 W93-70096  
Airborne ESTAR  
461-38-01 W93-70327  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Advanced Transmitter Systems Development  
310-20-64 W93-70538

**SUPERSONIC AIRCRAFT**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Flight Systems Research and Technology  
505-68-00 W93-70013  
Flight Systems Research and Technology  
505-68-00 W93-70014  
Advanced Turboprop Systems  
535-03-00 W93-70045

**SUPERSONIC BOUNDARY LAYERS**

Aerodynamics Research and Technology  
505-59-00 W93-70003

**SUPERSONIC COMBUSTION RAMJET ENGINES**

Hypersonic Research and Technology  
505-70-00 W93-70022

**SUPERSONIC COMMERCIAL AIR TRANSPORT**

Atmospheric Effects  
537-01-00 W93-70050

**SUPERSONIC FLIGHT**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Systems Analysis  
505-69-00 W93-70018

**SUPERSONIC FLOW**

High-Performance Flight Research  
533-02-00 W93-70041  
Emissions and Source Noise  
537-02-00 W93-70055  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Community Noise and Sonic Boom  
537-03-00 W93-70057

**SUPERSONIC JET FLOW**

Emissions and Source Noise  
537-02-00 W93-70055

**SUPERSONIC NOZZLES**

Emissions and Source Noise  
537-02-00 W93-70055

**SUPERSONIC TRANSPORTS**

Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Computational/Aeroscience  
509-10-00 W93-70031  
Atmospheric Effects  
537-01-00 W93-70050  
Atmospheric Effects  
537-01-00 W93-70051  
Atmospheric Effects  
537-01-00 W93-70052  
Emissions and Source Noise  
537-02-00 W93-70054  
Emissions and Source Noise  
537-02-00 W93-70055

**SUPPORT SYSTEMS**

Advanced Composite Materials Technology  
510-02-00 W93-70037  
Systems Analysis  
506-49-00 W93-70082  
Information and Controls Research and Technology  
506-59-00 W93-70092  
Human Support Research and Technology  
506-71-00 W93-70093  
Human Support Research and Technology  
506-71-00 W93-70095  
In-Space Experiments  
506-74-00 W93-70102  
In-Space Technology Experiments  
506-74-00 W93-70103

In-Space Technology Experiments  
506-74-00 W93-70107

Earth-to-Orbit Transportation  
584-03-00 W93-70121

Planetary Materials: General Operations and Laboratory  
Facilities  
152-30-40 W93-70150

Ground-Based Support of Solar Physics  
170-38-52 W93-70179

Structural Biosystems  
199-40-42 W93-70242

Solar Probe ATD  
433-06-00 W93-70296

Space Physics Program Support/Detailees  
433-90-00 W93-70297

Goldstone DOSE Support  
465-28-02 W93-70403

Hydrospheric Processes Program Support for Modeling  
and Data Analysis  
578-97-12 W93-70446

Planning and Scheduling Systems Technology  
310-20-36 W93-70534

Advanced Environments for Software and System  
Development  
310-40-49 W93-70549

**SUPPRESSORS**

Community Noise and Sonic Boom  
537-03-00 W93-70057

**SURFACE LAYERS**

ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407

**SURFACE PROPERTIES**

Planetology  
151-01-70 W93-70139  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Heterogeneous Scene Models  
462-61-03 W93-70347  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425

**SURFACE REACTIONS**

Materials and Structures Research and Technology  
506-43-00 W93-70071

**SURFACE ROUGHNESS**

Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348

**SURFACE TEMPERATURE**

In-Space Technology Experiments  
506-74-00 W93-70107  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Global Assessment of Active Volcanism  
429-81-94 W93-70285  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Scatterometer Studies  
461-31-13 W93-70324  
Forest/Climate Interactions  
462-21-00 W93-70337  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
An Integrated Study of Surface Property Variations  
578-12-02 W93-70425  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Subgrid Variation of Surface Parameters  
578-42-15 W93-70444  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468

**SURFACE VEHICLES**

Telepresence for Planetary Exploration  
186-06-01 W93-70182

**SURFACE WAVES**

Scatterometer Research  
461-31-09 W93-70323

**SURVEYS**

Astrotech 21  
188-78-44 W93-70215  
Earth Science Advanced Aircraft (ESAA)  
460-97-00 W93-70317  
Data Survey and Evaluation  
464-41-04 W93-70385

**SWEPT FORWARD WINGS**

High-Performance Flight Research  
533-02-00 W93-70041

**SWEPT WINGS**

Community Noise and Sonic Boom  
537-03-00 W93-70056



**SWITCHES**

Space Energy Conversion Research and Technology  
506-41-00 W93-70067

**SYNCHRONOUS PLATFORMS**

Information and Communications  
586-03-00 W93-70135

**SYNCHROTRON RADIATION**

Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204  
Magnetospheric Coupling  
432-36-00 W93-70293

**SYNTAX**

Data Interchange Standards  
656-61-03 W93-70479

**SYNTHETIC APERTURE RADAR**

Automated Geophysical Processor Development for the  
Alaska SAR Facility  
428-82-11 W93-70273  
Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Validations of Passive Microwave Snow Water  
Equivalent Algorithm  
461-13-00 W93-70319  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Polarimetric Data Analysis  
461-64-11 W93-70334  
Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Soil Moisture from SAR  
462-62-05 W93-70349  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
462-75-62 W93-70351  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
465-68-01 W93-70420  
Active/Passive Sea Ice Analysis  
578-32-24 W93-70437  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438  
Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate  
578-35-02 W93-70439  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466  
ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499  
ASF SAR Interferometry  
665-35-01 W93-70500  
Estimation of Greenland Sea Brine and Freshwater  
Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501  
ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502  
Advanced Search and Rescue Techniques  
669-30-10 W93-70504

**SYNTHETIC APERTURES**

Airborne ESTAR  
461-38-01 W93-70327  
Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338

**SYSTEM IDENTIFICATION**

Earth-Orbiting Platforms  
585-03-00 W93-70126

**SYSTEMS ANALYSIS**

Systems Analysis  
505-69-00 W93-70016  
Systems Analysis  
505-69-00 W93-70017  
Systems Analysis  
505-69-00 W93-70018  
Systems Analysis  
505-69-00 W93-70019  
Hypersonic Research and Technology  
505-70-00 W93-70023  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066

Space Flight Research and Technology  
506-48-00 W93-70078  
Systems Analysis  
506-49-00 W93-70082  
Systems Analysis  
506-49-00 W93-70084  
Systems Analysis  
506-49-00 W93-70085  
Human Support Research and Technology  
506-71-00 W93-70095  
Hypersonic Research and Technology  
506-73-00 W93-70101  
Surface Systems  
583-02-00 W93-70116  
Stratospheric Observatory for Infrared Astronomy  
(SOFIA)  
188-78-60 W93-70216  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
462-75-62 W93-70351  
Computer and Information Systems Support  
579-82-90 W93-70474

**SYSTEMS ENGINEERING**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Systems Analysis  
505-69-00 W93-70016  
Systems Analysis  
505-69-00 W93-70019  
Advanced Rotorcraft Technology  
532-06-00 W93-70040  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064  
Materials and Structures Research and Technology  
506-43-00 W93-70073  
Space Flight Research and Technology  
506-48-00 W93-70079  
Space Flight Research and Technology  
506-48-00 W93-70081  
Systems Analysis  
506-49-00 W93-70082  
Systems Analysis  
506-49-00 W93-70084  
University Space Engineering Research  
506-50-00 W93-70086  
Surface Systems  
583-02-00 W93-70116  
Space Transportation  
584-04-00 W93-70122  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166  
IPAC Astrophysics Data System (ADS) Support  
399-20-00 W93-70258  
Solar Probe ATD  
433-06-00 W93-70296  
Information Systems Newsletter  
656-50-65 W93-70477  
Data Interchange Standards  
656-61-03 W93-70479  
Software Engineering Technology  
310-10-23 W93-70527  
Flight Dynamics Technology  
310-10-26 W93-70528  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534  
Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537  
Advanced Transmitter Systems Development  
310-20-64 W93-70538  
Antenna Systems Development  
310-20-65 W93-70539  
Radio Systems Development  
310-20-66 W93-70540  
Communication Systems Research  
310-30-71 W93-70544  
Human-to-Machine Interface Technology  
310-40-37 W93-70545  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549  
Atmospheric Effects  
537-01-00 W93-70049  
Human Support Research and Technology  
506-71-00 W93-70095  
Information and Communications  
586-02-00 W93-70134  
IPAC Astrophysics Data System (ADS) Support  
399-20-00 W93-70258  
Data System Integration (Commonality and  
Interoperability)  
656-61-02 W93-70478

A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496

**T****TAKEOFF**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Flight Systems Research and Technology  
505-68-00 W93-70013  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Community Noise and Sonic Boom  
537-03-00 W93-70057

**TASK COMPLEXITY**

Expert Systems for Automation of Operations  
310-40-47 W93-70547

**TASKS**

Information and Controls Research and Technology  
506-59-00 W93-70092  
Expert Systems for Automation of Operations  
310-40-47 W93-70547

**TAYLOR SERIES**

Modeling of the Main Magnetic Field  
579-31-02 W93-70457

**TDR SATELLITES**

Flight Dynamics Technology  
310-10-26 W93-70528  
Optical Communications  
310-20-35 W93-70533  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549

**TEA LASERS**

Wind Measurement Assessment  
460-28-41 W93-70314

**TECHNOLOGICAL FORECASTING**

Astrotech 21  
188-78-44 W93-70215  
Software Engineering Technology  
310-10-23 W93-70527

**TECHNOLOGY ASSESSMENT**

Systems Analysis  
505-69-00 W93-70016  
Enabling Propulsion Materials  
537-04-00 W93-70058  
Systems Analysis  
506-49-00 W93-70084  
Human Support Research and Technology  
506-71-00 W93-70095  
In-Space Technology Experiments  
506-74-00 W93-70103  
Space Transportation  
584-04-00 W93-70122  
Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480  
Software Engineering Technology  
310-10-23 W93-70527

**TECHNOLOGY TRANSFER**

Aging Aircraft  
538-02-00 W93-70061  
Space Communications Research and Technology  
506-72-00 W93-70097  
Automation and Robotics  
586-02-00 W93-70127  
Automation and Robotics  
586-02-00 W93-70128  
Automation and Robotics  
586-02-00 W93-70132  
Automation and Robotics  
586-02-00 W93-70133  
Astrotech 21  
188-78-44 W93-70215  
Musculoskeletal  
199-26-14 W93-70238  
Communication Systems Research  
310-30-71 W93-70544  
Human-to-Machine Interface Technology  
310-40-37 W93-70545

**TECHNOLOGY UTILIZATION**

Aerodynamics Research and Technology  
505-59-00 W93-70002  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
Advanced Rotorcraft Technology  
532-06-00 W93-70040  
Atmospheric Effects  
537-01-00 W93-70052  
Emissions and Source Noise  
537-02-00 W93-70055  
Community Noise and Sonic Boom  
537-03-00 W93-70057  
Information and Controls Research and Technology  
506-59-00 W93-70089

**TECTONICS**

- Space Communications Research and Technology  
506-72-00 W93-70097
- Science Sensing (Remote)  
582-03-00 W93-70109
- Observatory Systems  
582-04-00 W93-70114
- Automation and Robotics  
586-02-00 W93-70128
- Information and Communications  
586-03-00 W93-70137
- Infrared and Radio Astrophysics Technical  
Development: Ground-Based Astronomical Instrument  
188-44-23 W93-70195
- NSSDC Astrophysics Data Systems Support  
656-61-17 W93-70484
- Consulting and Program Support  
674-29-08 W93-70520
- Networks Communication Technology  
310-20-38 W93-70536
- Expert Systems for Automation of Operations  
310-40-47 W93-70547

**TECTONICS**

- Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388
- Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389
- GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391
- Active Deformation in the Mojave Desert and Walker  
Lane: A Global Positioning System Experiment  
465-13-06 W93-70392
- Global Tectonic Motions  
465-14-01 W93-70394
- Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395
- Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402
- Goldstone DOSE Support  
465-28-02 W93-70403
- Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408
- Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409
- Evolution of Volcanic Terrains  
465-44-02 W93-70412
- Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459
- Earth Rotation and Mantle Structure  
579-36-03 W93-70460

**TELECOMMUNICATION**

- Space Communications Research and Technology  
506-72-00 W93-70096
- Communications and Telemetry  
310-20-37 W93-70535
- Advanced Space Systems for Users of NASA  
Networks  
310-20-46 W93-70537
- Optical Communications Technology Development  
310-20-67 W93-70541
- Communication Systems Research  
310-30-71 W93-70544

**TELEMETRY**

- Archival Task for the Equatorial San Marco D, AE and  
DE Satellite Missions  
370-03-00 W93-70255
- GPS-Based DSN Calibration System  
310-10-61 W93-70530
- Communications and Telemetry  
310-20-37 W93-70535
- Radio Systems Development  
310-20-66 W93-70540
- Network Signal Processing  
310-30-70 W93-70543
- Communication Systems Research  
310-30-71 W93-70544
- Mission Operations Technology  
310-40-45 W93-70546
- Data Storage Technology  
310-40-48 W93-70548
- Advanced Telemetry Processing Technology  
310-40-51 W93-70550

**TELEOPERATORS**

- Automation and Robotics  
586-02-00 W93-70129
- Automation and Robotics  
586-02-00 W93-70130
- Telepresence for Planetary Exploration  
186-06-01 W93-70182
- Exploration Exobiology  
199-52-82 W93-70251

**TELEROBOTICS**

- Information and Controls Research and Technology  
506-59-00 W93-70087
- Information and Controls Research and Technology  
506-59-00 W93-70089
- Automation and Robotics  
586-02-00 W93-70129
- Automation and Robotics  
586-02-00 W93-70130
- Automation and Robotics  
586-02-00 W93-70132

**TELESCOPES**

- Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172
- Mars Lidar (Lidar from the Mars Surface and Mars Orbit  
for Atmospheric Studies)  
157-03-90 W93-70173
- Ground-Based Support of Solar Physics  
170-38-52 W93-70179
- UV Astronomy and Data Systems  
188-41-51 W93-70189
- Submillimeter Astronomy  
188-44-23 W93-70194
- Stratospheric Observatory for Infrared Astronomy  
(SOFIA)  
188-78-60 W93-70216
- Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217
- Ground-Based Infrared Astronomy  
196-41-50 W93-70218
- NDSC Differential Absorption Lidar  
464-13-15 W93-70371
- Astrometric Development Technology  
310-10-60 W93-70529
- Optical Communications Technology Development  
310-20-67 W93-70541

**TELEVISION SYSTEMS**

- U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166

**TEMPERATE REGIONS**

- Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316
- Biogeochemical Research in Temperate Ecosystems  
462-43-00 W93-70345
- Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363
- Lower Stratosphere Aircraft Data Analysis  
464-34-00 W93-70384

**TEMPERATURE CONTROL**

- Hypersonic Research and Technology  
505-70-00 W93-70022
- Space Energy Conversion Research and Technology  
506-41-00 W93-70064
- Space Energy Conversion Research and Technology  
506-41-00 W93-70066
- In-Space Technology Experiments  
506-74-00 W93-70103
- In-Space Experiments  
506-74-00 W93-70105
- Surface Systems  
583-02-00 W93-70116
- Microgravity Nucleation and Particle  
Coagulation Experiments  
152-20-01 W93-70148

**TEMPERATURE DEPENDENCE**

- Quantitative Infrared Spectroscopy of Minor  
Constituents of the Earth's Stratosphere  
464-23-00 W93-70380
- Laser Laboratory Spectroscopy  
464-23-09 W93-70382

**TEMPERATURE DISTRIBUTION**

- Materials and Structures Research and Technology  
505-63-00 W93-70009
- Propulsion Research and Technology  
506-42-00 W93-70070
- Materials and Structures Research and Technology  
506-43-00 W93-70074
- Space Flight Research and Technology  
506-48-00 W93-70080
- Optical Interferometry in Space  
188-78-41 W93-70213
- Global Assessment of Active Volcanism  
428-81-94 W93-70269
- Global Assessment of Active Volcanism  
429-81-94 W93-70285
- Global Assessment of Active Volcanism  
429-81-97 W93-70288
- Microwave Temperature Profiler  
464-14-20 W93-70374
- Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399
- Volcanic Cloud Dispersion, Chemistry and Microphysics:  
An Analysis of the El Chichon Eruption  
465-44-06 W93-70415

- Meteorological Parameters Extraction  
578-12-20 W93-70427
- SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521
- Neptune Data Analysis  
889-59-00 W93-70524

**TEMPERATURE EFFECTS**

- IR Astronomy ATD/Cryo Optical Testing and Science  
Support Activities  
188-78-44 W93-70214
- Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Data Analysis  
578-10-00 W93-70421
- Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Modeling  
578-40-00 W93-70441

**TEMPERATURE GRADIENTS**

- Earth-To-Orbit Transportation  
584-03-00 W93-70119
- Microgravity Nucleation and Particle  
Coagulation Experiments  
152-20-01 W93-70148
- Global Assessment of Active Volcanism  
429-81-94 W93-70285
- Global Assessment of Active Volcanism  
429-81-97 W93-70288
- Metals and Alloys  
674-25-08 W93-70514

**TEMPERATURE PROFILES**

- In-Space Technology Experiments  
506-74-00 W93-70107
- Microwave Temperature Profiler  
464-14-20 W93-70374
- Meteorological Parameters Extraction  
578-12-20 W93-70427
- Soil/Canopy Moisture and Temperature Profiles Using  
Remote Sensing and Modeling  
579-42-13 W93-70471

**TEMPERATURE SENSORS**

- Advanced High Temperature Engine Materials  
510-01-00 W93-70036

**TEMPORAL DISTRIBUTION**

- Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341
- Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357
- Airborne IR Spectrometry  
464-12-00 W93-70367
- Geopotential Temporal Variations  
465-17-02 W93-70400
- Modeling of the Main Magnetic Field  
579-31-02 W93-70457
- ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466
- Spatial and Temporal Distribution of Biomass  
Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472

**TEMPORAL RESOLUTION**

- Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191
- Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402
- Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523

**TENDONS**

- Musculoskeletal (Biomedical)  
199-26-12 W93-70237

**TENSORS**

- Kinematic Models Combining VLBI, GPS, and  
Trilateration Data and Plate Constraints  
465-14-07 W93-70395

**TERPENES**

- Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386

**TERRACES (LANDFORMS)**

- Carbon Mass Balance During Soil Evolution Along  
Climate Gradients  
465-45-01 W93-70416

**TERRAIN**

- Forest/Climate Interactions  
462-21-00 W93-70337
- Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348
- Airborne Interferometric Topography  
462-74-01 W93-70350
- Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
465-43-03 W93-70409
- Evolution of Volcanic Terrains  
465-44-02 W93-70412
- Airborne Interferometric Topography  
465-67-04 W93-70419

- Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439
- TERRESTRIAL PLANETS**  
Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222
- TEST EQUIPMENT**  
Hypersonic Research and Technology  
506-73-00 W93-70101
- TEST FACILITIES**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Earth-Orbiting Platforms  
585-03-00 W93-70126  
Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253
- TEST STANDS**  
Flight Systems Research and Technology  
505-68-00 W93-70013  
Earth and Space Sciences  
509-20-00 W93-70034  
Human Support Research and Technology  
506-71-00 W93-70093
- TESTS**  
Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470  
Fluid Physics  
674-24-08 W93-70512
- THEMATIC MAPPERS (LANDSAT)**  
Foreign Visitor Support  
429-97-04 W93-70290  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321  
Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408  
Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
579-42-02 W93-70468  
Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472
- THEMATIC MAPPING**  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407
- THEORETICAL PHYSICS**  
Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178  
Space Physics Theory Program  
431-06-00 W93-70291
- THERMAL CONDUCTIVITY**  
Surface Systems  
583-02-00 W93-70117  
Solar Probe ATD  
433-06-00 W93-70296
- THERMAL ENERGY**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Global Assessment of Active Volcanism  
429-81-94 W93-70285
- THERMAL FATIGUE**  
Enabling Propulsion Materials  
537-04-00 W93-70058
- THERMAL MAPPING**  
Mars Atmosphere Dust Opacity  
155-04-00 W93-70163
- THERMAL PROTECTION**  
Hypersonics Research and Technology  
506-73-00 W93-70100  
Automation and Robotics  
586-02-00 W93-70133
- THERMAL STABILITY**  
Observatory Systems  
582-04-00 W93-70114
- THERMAL STRESSES**  
Materials and Structures Research and Technology  
506-43-00 W93-70074
- THERMOCHEMISTRY**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062
- THERMODYNAMIC CYCLES**  
Systems Analysis  
505-69-00 W93-70018  
GA/Commuter Engine Technology  
535-05-00 W93-70046
- THERMODYNAMIC EFFICIENCY**  
Space Flight Research and Technology  
506-48-00 W93-70078  
Observatory Systems  
582-04-00 W93-70115
- THERMODYNAMIC PROPERTIES**  
In-Space Technology Experiments  
506-74-00 W93-70106  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Global Assessment of Active Volcanism  
429-81-94 W93-70285  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399
- THERMODYNAMICS**  
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling  
578-40-00 W93-70441
- THERMOELECTRIC MATERIALS**  
Surface Systems  
583-02-00 W93-70117
- THERMOELECTRIC POWER GENERATION**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70065  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067  
Surface Systems  
583-02-00 W93-70117
- THERMOMETERS**  
High Throughput X-Ray Spectroscopy  
188-46-59 W93-70210
- THERMOPHILES**  
The Early Evolution of Life  
199-52-32 W93-70248
- THERMOREGULATION**  
Regulatory Physiology (Biomedical)  
199-18-12 W93-70235
- THERMOSPHERE**  
Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions  
432-48-00 W93-70294
- THIN FILMS**  
Materials and Structures Research and Technology  
506-43-00 W93-70073
- THREE DIMENSIONAL MODELS**  
EOS IDS, EOSDIS Money  
428-81-36 W93-70266  
Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption  
465-44-06 W93-70415  
Climate Modeling with Emphasis on Aerosols and Clouds  
578-11-01 W93-70422  
An Ocean General Circulation Model for Climate Studies  
578-41-43 W93-70443  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452  
Simulation of Tropospheric Ozone  
579-24-00 W93-70453  
Global Tropospheric Modeling of Trace Gases  
579-24-06 W93-70454  
Climatological Stratospheric Modeling  
579-24-09 W93-70455  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488
- THROTTLING**  
Propulsion Research and Technology  
506-42-00 W93-70070
- THRUST**  
GA/Commuter Engine Technology  
535-05-00 W93-70046
- THRUST VECTOR CONTROL**  
Propulsion and Power  
505-62-00 W93-70005  
Flight Systems Research and Technology  
505-68-00 W93-70013  
Flight Systems Research and Technology  
505-68-00 W93-70015
- TIDES**  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461
- TILES**  
Automation and Robotics  
586-02-00 W93-70133
- TIME**  
Magnetospheric Coupling  
432-36-00 W93-70293
- TIME DEPENDENCE**  
Materials and Structures Research and Technology  
505-63-00 W93-70007  
Computational Aerosciences  
509-10-00 W93-70030  
Origins of Solar Systems  
452-23-94 W93-70305  
Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388  
North American Fiducial Network  
465-14-11 W93-70397  
Geopotential Temporal Variations  
465-17-02 W93-70400
- TIME MARCHING**  
Mars 3-D Global Circulation Model  
154-95-80 W93-70161
- TIME MEASUREMENT**  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457  
Frequency and Timing Research  
310-10-62 W93-70531
- TIME SERIES ANALYSIS**  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
- TITAN**  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155
- TOLERANCES (MECHANICS)**  
Advanced Rotorcraft Technology  
532-06-00 W93-70040
- TOMOGRAPHY**  
Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460
- TOPEX**  
Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Goldstone DOSE Support  
465-28-02 W93-70403  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Radar-Altimeter Ice Data System  
578-97-20 W93-70448  
Data Interchange Standards  
656-61-03 W93-70479
- TOPOGRAPHY**  
Science Sensing (Remote)  
582-03-00 W93-70111  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Validations of Passive Microwave Snow Water Equivalent Algorithm  
461-13-00 W93-70319  
Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328  
Heterogeneous Scene Models  
462-61-03 W93-70347  
Airborne Interferometric Topography  
462-74-01 W93-70350  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Radar-Altimeter Ice Data System  
578-97-20 W93-70448

Topography from SEASAT and GEOSAT Overland  
 Altimetry  
 579-42-03 W93-70469  
 ASF SAR Interferometry  
 665-35-01 W93-70500  
 Neptune Data Analysis Program  
 889-59-00 W93-70526  
**TOTAL OZONE MAPPING SPECTROMETER**  
 Studies of Volcanic SO<sub>2</sub>  
 428-81-99 W93-70271  
 IDS Science for WHOI/GSFC Eos Project:  
 Biogeochemical Fluxes at the Air-Sea Interface  
 429-81-80 W93-70284  
 Studies of Volcanic SO<sub>2</sub>, Theory  
 429-81-99 W93-70289  
 Stratospheric Chemical Model: Dynamics  
 579-23-10 W93-70452  
**TOUCH**  
 Automation and Robotics  
 586-02-00 W93-70132  
**TOXICOLOGY**  
 Environmental Health  
 199-04-11 W93-70227  
**TRACE CONTAMINANTS**  
 Biogeochemical Research in Tropical Ecosystems:  
 Mechanisms of Trace Gas Production  
 463-61-00 W93-70361  
 Simulation of Tropospheric Ozone  
 579-24-00 W93-70453  
 Global Tropospheric Modeling of Trace Gases  
 579-24-06 W93-70454  
 Spatial and Temporal Distribution of Biomass  
 Combustion and Pyrogenic Trace Gas Emissions  
 579-43-00 W93-70472  
**TRACE ELEMENTS**  
 Planetary Materials: Chemistry  
 152-13-40 W93-70144  
 EOS IDS, EOSDIS Money  
 428-81-36 W93-70266  
 EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea  
 Interface  
 428-81-80 W93-70268  
 EOS IDS, Stratospheric Temperature and Trace Gas  
 Trends  
 429-81-36 W93-70280  
 Studies of Volcanic SO<sub>2</sub>, Theory  
 429-81-99 W93-70289  
 Laser Diode Sensor  
 464-11-07 W93-70366  
 IR Solar Absorption Spectra  
 464-12-05 W93-70368  
 Stratospheric Processes and Atmospheric Chemistry  
 Studies  
 464-14-00 W93-70373  
 Quantitative Infrared Spectroscopy of Minor  
 Constituents of the Earth's Stratosphere  
 464-23-00 W93-70380  
 Infrared Laboratory Spectroscopy in Support of  
 Stratospheric Measurements  
 464-23-08 W93-70381  
 Two-Dimensional Stratospheric Chemical Model -  
 Radiation  
 579-23-01 W93-70451  
 Stratospheric Chemical Model: Dynamics  
 579-23-10 W93-70452  
 Spatial and Temporal Distribution of Biomass  
 Combustion and Pyrogenic Trace Gas Emissions  
 579-43-00 W93-70472  
**TRACKING (POSITION)**  
 Relativity, Cosmology, and Gravitational Radiation  
 188-41-22 W93-70185  
**TRAJECTORY ANALYSIS**  
 Wind Measurement Assessment  
 460-28-41 W93-70314  
**TRAJECTORY CONTROL**  
 Information and Controls Research and Technology  
 506-59-00 W93-70092  
**TRANSATMOSPHERIC VEHICLES**  
 Hypersonic Research and Technology  
 505-70-00 W93-70022  
 Hypersonics Research and Technology  
 506-73-00 W93-70100  
**TRANSFORMATIONS (MATHEMATICS)**  
 Two-Dimensional Stratospheric Chemical Model -  
 Radiation  
 579-23-01 W93-70451  
**TRANSIENT RESPONSE**  
 Earth-Orbiting Platforms  
 585-03-00 W93-70124  
**TRANSITION METALS**  
 Surface Systems  
 583-02-00 W93-70117  
**TRANSITION PROBABILITIES**  
 Aerothermodynamics Research and Technology  
 506-40-00 W93-70062

Theory, Laboratory and Data Analysis for Solar  
 Physics  
 170-38-53 W93-70180  
**TRANSLATIONAL MOTION**  
 Kinematic Models Combining VLBI, GPS, and  
 Trilateration Data and Plate Constraints  
 465-14-07 W93-70395  
**TRANSMISSIONS (MACHINE ELEMENTS)**  
 Propulsion and Power Research and Technology  
 505-62-00 W93-70004  
**TRANSMITTER RECEIVERS**  
 Space Communications Research and Technology  
 506-72-00 W93-70099  
 Science Sensing (Remote)  
 582-03-00 W93-70111  
 Information and Communications  
 586-03-00 W93-70135  
**TRANSMITTERS**  
 Science Sensing (Remote)  
 582-03-00 W93-70110  
 Science Sensing (Remote)  
 582-03-00 W93-70113  
 Advanced Transmitter Systems Development  
 310-20-64 W93-70538  
**TRANSPIRATION**  
 Visiting Scientists  
 462-76-49 W93-70353  
**TRANSPONDERS**  
 Monitoring Global Sea Level with Altimeter  
 Transponders  
 461-38-02 W93-70328  
 ERS-1 Radar Permafrost Penetration  
 465-41-01 W93-70407  
**TRANSPORT AIRCRAFT**  
 Propulsion and Power Research and Technology  
 505-62-00 W93-70004  
 Systems Analysis  
 505-69-00 W93-70019  
 Advanced High Temperature Engine Materials  
 510-01-00 W93-70036  
 High-Performance Flight Research  
 533-02-00 W93-70043  
 Advanced Turboprop Systems  
 535-03-00 W93-70045  
 Atmospheric Effects  
 537-01-00 W93-70049  
 Emissions and Source Noise  
 537-02-00 W93-70055  
 Fly-By-Light/Power-By-Wire Technology  
 538-01-00 W93-70059  
 Fly-By-Light/Power-By-Wire  
 538-01-00 W93-70060  
 Aging Aircraft  
 538-02-00 W93-70061  
**TRANSPORT PROPERTIES**  
 Planetary Aeronomy: Theory and Analysis  
 154-60-80 W93-70157  
 Convective Transport in the Solar Nebula  
 452-22-91 W93-70303  
 Electronic Materials  
 674-21-05 W93-70505  
 Fluid Physics  
 674-24-05 W93-70511  
**TRANSPORT THEORY**  
 Cosmic and Heliospheric Physics  
 170-10-10 W93-70176  
 Theory, Laboratory and Data Analysis for Solar  
 Physics  
 170-38-53 W93-70180  
 Magnetospheric Coupling  
 432-36-00 W93-70293  
**TRAPPED PARTICLES**  
 Frequency and Timing Research  
 310-10-62 W93-70531  
**TRIGONOMETRIC FUNCTIONS**  
 HIPPARCOS VLBI  
 399-18-00 W93-70256  
**TRITON**  
 Neptune Data Analysis  
 889-59-00 W93-70525  
**TROPICAL REGIONS**  
 Role of Air-Sea Exchanges and Ocean Circulation  
 (Computing)  
 428-81-10 W93-70263  
 Foreign Visitor Support  
 429-97-04 W93-70290  
 IR Remote Sensing of SST  
 460-21-28 W93-70310  
 Radiative Effects in Clouds First International Satellite  
 Cloud Climatology Regional Experiment  
 460-42-00 W93-70315  
 TRMM  
 461-38-05 W93-70329  
 Airborne Precipitation Radar  
 461-51-16 W93-70332

Biogeochemical Research in Tropical Ecosystems:  
 Mechanisms of Trace Gas Production  
 463-61-00 W93-70361  
 Lower Stratosphere Aircraft Data Analysis  
 464-34-00 W93-70384  
 Tropical Ocean Circulation from Altimetry and Numerical  
 Modeling  
 578-21-12 W93-70430  
 Large Scale Air-Sea Interactions  
 578-22-26 W93-70433  
 Spatial and Temporal Distribution of Biomass  
 Combustion and Pyrogenic Trace Gas Emissions  
 579-43-00 W93-70472  
**TROPOPAUSE**  
 Atmospheric Backscatter Experiment  
 460-22-53 W93-70313  
 Stratospheric Processes and Atmospheric Chemistry  
 Studies  
 464-14-00 W93-70373  
**TROPOSPHERE**  
 Atmospheric Effects  
 537-01-00 W93-70052  
 EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea  
 Interface  
 428-81-80 W93-70268  
 IDS Science for WHOI/GSFC Eos Project:  
 Biogeochemical Fluxes at the Air-Sea Interface  
 429-81-80 W93-70284  
 Airborne Doppler Lidar  
 460-21-52 W93-70311  
 Atmospheric Backscatter Experiment  
 460-22-53 W93-70313  
 Wind Measurement Assessment  
 460-28-41 W93-70314  
 Multidimensional Studies of Tropospheric Clouds  
 460-47-00 W93-70316  
 NDSC Differential Absorption Lidar  
 464-13-15 W93-70371  
 Stratospheric Processes and Atmospheric Chemistry  
 Studies  
 464-14-00 W93-70373  
 Kinetics of Tropospheric and Stratospheric Reactions  
 464-21-06 W93-70378  
 Lower Stratosphere Aircraft Data Analysis  
 464-34-00 W93-70384  
 Kinetic Studies of Tropospheric Free Radicals  
 464-53-01 W93-70386  
 Global Tropospheric Experiment Aircraft,  
 Measurements  
 464-54-00 W93-70387  
 Parkfield GPS Experiment  
 465-13-08 W93-70393  
 GPS/VLBI Vertical Measurement  
 465-14-09 W93-70396  
 Short-Period Tropospheric Noise in Continuous GPS  
 Measurements  
 465-27-02 W93-70402  
 Stratospheric Chemical Model: Dynamics  
 579-23-10 W93-70452  
 Simulation of Tropospheric Ozone  
 579-24-00 W93-70453  
 Global Tropospheric Modeling of Trace Gases  
 579-24-06 W93-70454  
 Climatological Stratospheric Modeling  
 579-24-09 W93-70455  
 Spatial and Temporal Distribution of Biomass  
 Combustion and Pyrogenic Trace Gas Emissions  
 579-43-00 W93-70472  
 Astrometric Development Technology  
 310-10-60 W93-70529  
**TRUSSES**  
 Automation and Robotics  
 586-02-00 W93-70129  
**TUNABLE LASERS**  
 Laboratory Astrophysics  
 188-44-57 W93-70203  
 Quantitative Infrared Spectroscopy of Minor  
 Constituents of the Earth's Stratosphere  
 464-23-00 W93-70380  
**TUNDRA**  
 Regional Carbon Flux in High Latitude Ecosystems  
 463-43-00 W93-70359  
**TUNGSTEN**  
 Materials and Structures Research and Technology  
 506-43-00 W93-70076  
**TUNING**  
 Imaging Spectropolarimeter  
 157-03-70 W93-70170  
**TURBINE ENGINES**  
 GA/Commuter Engine Technology  
 535-05-00 W93-70046  
**TURBINE PUMPS**  
 Earth-to-Orbit Transportation  
 584-03-00 W93-70121

**TURBOFAN ENGINES**

- Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Advanced Turboprop Systems  
535-03-00 W93-70044

**TURBULENCE**

- Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Aerodynamics Research and Technology  
505-59-00 W93-70003  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303

**TURBULENCE EFFECTS**

- Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178  
Optical Technology for Space Astronomy  
188-41-23 W93-70186

**TURBULENCE MODELS**

- Hypersonic Research and Technology  
505-70-00 W93-70022

**TURBULENT FLOW**

- Emissions and Source Noise  
537-02-00 W93-70053  
Convective Transport in the Solar Nebula  
452-22-91 W93-70303  
Two-Phase Nebulae  
452-22-93 W93-70304

**TWO DIMENSIONAL MODELS**

- Two-Dimensional Stratospheric Chemical Model - Radiation  
579-23-01 W93-70451  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

**TWO PHASE FLOW**

- In-Space Experiments  
506-74-00 W93-70105

**U****U.S.S.R.**

- Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360

**U.S.S.R. SPACE PROGRAM**

- Mars Data Analysis  
155-20-00 W93-70164  
U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy  
155-20-02 W93-70166  
Mars 94 Gravity  
155-20-03 W93-70167

**U-2 AIRCRAFT**

- Microwave Temperature Profiler  
464-14-20 W93-70374

**ULTRAHIGH FREQUENCIES**

- Airborne ESTAR  
461-38-01 W93-70327  
Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Interferometric Topography  
465-67-04 W93-70419

**ULTRAVIOLET ASTRONOMY**

- UV Astronomy and Data Systems  
188-41-51 W93-70189

**ULTRAVIOLET PHOTOMETRY**

- Ozone Measurements  
464-11-05 W93-70365

**ULTRAVIOLET RADIATION**

- Optical Technology for Space Astronomy  
188-41-23 W93-70186  
Band Structure Engineering on Silicon CCDs for Enhanced UV Response  
188-41-24 W93-70188  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289

**ULTRAVIOLET SPECTRA**

- Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
The Nature of Interstellar Dust, Ices and Polycyclic Aromatic Hydrocarbons  
399-50-00 W93-70261

**ULTRAVIOLET SPECTROMETERS**

- In-Space Technology Experiments  
506-74-00 W93-70107  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521

**UNITED STATES**

- Mars Data Analysis  
155-20-00 W93-70164

**UNIVERSAL TIME**

- Theory of Geodetic Transformations  
465-15-06 W93-70398  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460

**UNIVERSE**

- Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196  
Theory and Modeling: Infrared, Submillimeter, and Radio  
188-44-53 W93-70200

**UNIVERSITIES**

- Interdisciplinary Technology  
505-90-00 W93-70024  
Interdisciplinary Technology  
505-90-00 W93-70026  
Interdisciplinary Technology  
505-90-00 W93-70027  
Graduate Fellowships  
578-97-16 W93-70447  
Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491

**UNIVERSITY PROGRAM**

- Hypersonic Training and Research  
505-70-00 W93-70021  
Interdisciplinary Technology  
505-90-00 W93-70024  
Interdisciplinary Technology  
505-90-00 W93-70025  
Interdisciplinary Technology  
505-90-00 W93-70026  
Interdisciplinary Technology  
505-90-00 W93-70027  
University Space Engineering Research  
506-50-00 W93-70086

**UNIX (OPERATING SYSTEM)**

- JPL Oceanography Group Common Computer System  
578-22-27 W93-70434  
LTP Visualization  
578-97-53 W93-70449  
LTP Computer Support  
579-41-04 W93-70465  
A Distributed Analysis and Visualization System for Model and Observational Data  
656-65-27 W93-70497

**UNSTEADY AERODYNAMICS**

- Materials and Structures Research and Technology  
505-63-00 W93-70009  
Flight Systems Research and Technology  
505-68-00 W93-70015

**UPGRADING**

- Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

**UPLINKING**

- Advanced Transmitter Systems Development  
310-20-64 W93-70538  
Antenna Systems Development  
310-20-65 W93-70539

**UPPER ATMOSPHERE**

- Ozone Measurements  
464-11-05 W93-70365  
Laser Diode Sensor  
464-11-07 W93-70366  
MM and Sub-MM Radiometry  
464-12-06 W93-70369  
Multi-Sensor Balloon Measurements  
464-16-01 W93-70375  
Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379  
Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

**UPPER ATMOSPHERE RESEARCH SATELLITE (UARS)**

- EOS IDS, Stratospheric Temperature and Trace Gas Trends  
429-81-36 W93-70280  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371

**UPWELLING WATER**

- Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357

**USER REQUIREMENTS**

- Earth-Orbiting Platforms  
585-03-00 W93-70126  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534  
Advanced Space Systems for Users of NASA Networks  
310-20-46 W93-70537

**V****V/STOL AIRCRAFT**

- Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Flight Systems Research and Technology  
505-68-00 W93-70013

**VALLEYS**

- Telepresence for Planetary Exploration  
186-06-01 W93-70182

**VAPOR DEPOSITION**

- Electronic Materials  
674-21-05 W93-70505  
Electronic Materials  
674-21-08 W93-70506  
Fluid Physics  
674-24-00 W93-70510

**VAPOR PHASES**

- Two-Phase Nebulae  
452-22-93 W93-70304

**VARIABILITY**

- 4D Data Assimilation for EOS  
429-81-04 W93-70275  
Magnetospheric Coupling  
432-36-00 W93-70293  
Land Surface Climatology: HAPEX  
462-32-00 W93-70340  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
An Ocean General Circulation Model for Climate Studies  
578-41-43 W93-70443  
Biogeochemistry and Geophysics Modeling and Data Analysis  
579-42-01 W93-70467

**VARIATIONS**

- Core-Mantle Excitation  
579-36-11 W93-70463

**VAX COMPUTERS**

- JPL Oceanography Group Common Computer System  
578-22-27 W93-70434  
Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459  
LTP Computer Support  
579-41-04 W93-70465

**VAX-11/780 COMPUTER**

- EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface  
428-81-80 W93-70268

**VEGETATION**

- Validations of Passive Microwave Snow Water Equivalent Algorithm  
461-13-00 W93-70319  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321  
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress  
462-31-63 W93-70339  
Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production  
463-61-00 W93-70361  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362  
Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
579-42-13 W93-70471  
Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
656-65-22 W93-70493  
ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems  
665-35-00 W93-70499

**VEGETATION GROWTH**

- Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254

**VEGETATIVE INDEX**

- Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
461-13-01 W93-70321  
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions  
579-42-02 W93-70468

**VELOCITY DISTRIBUTION**

- Ground-Based Support of Solar Physics  
170-38-52 W93-70179
- Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180
- Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389
- Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395
- Large Scale Air-Sea Interactions  
578-22-26 W93-70433
- ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502
- Neptune Data Analysis Program  
889-59-00 W93-70526

**VELOCITY MEASUREMENT**

- CO2 Lidar Backscatter Experiment  
460-21-00 W93-70309
- Astrometric Development Technology  
310-10-60 W93-70529

**VENUS (PLANET)**

- Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178

**VENUS ATMOSPHERE**

- Dynamics of Planetary Atmospheres  
154-20-80 W93-70153

**VERTEBRATES**

- Structural Biosystems  
199-40-42 W93-70242

**VERTICAL DISTRIBUTION**

- Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158
- NDSC Differential Absorption Lidar  
464-13-15 W93-70371
- Multi-Sensor Balloon Measurements  
464-16-01 W93-70375

**VERTICAL LANDING**

- Propulsion and Power Research and Technology  
505-62-00 W93-70004
- Flight Systems Research and Technology  
505-68-00 W93-70013

**VERTICAL MOTION SIMULATORS**

- Flight Systems Research and Technology  
505-68-00 W93-70013

**VERTICAL ORIENTATION**

- Cell and Developmental Biology  
199-40-22 W93-70240

**VERY LARGE SCALE INTEGRATION**

- Space Data Systems  
586-03-00 W93-70136
- Information and Communications  
586-03-00 W93-70137
- Network Signal Processing  
310-30-70 W93-70543
- Data Storage Technology  
310-40-48 W93-70548

**VERY LONG BASE INTERFEROMETRY**

- Observatory Systems  
582-04-00 W93-70114
- Observatory Systems  
582-04-00 W93-70115
- Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151
- Infrared/Radio Research  
188-44-21 W93-70193
- HIPPARCOS VLBI  
399-18-00 W93-70256
- Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328
- Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389
- Dynamics of North American-Pacific Shear  
465-13-02 W93-70390
- Global Tectonic Motions  
465-14-01 W93-70394
- Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395
- GPS/VLBI Vertical Measurement  
465-14-09 W93-70396
- North American Fiducial Network  
465-14-11 W93-70397
- Goldstone DOSE Support  
465-28-02 W93-70403
- Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459
- Astrometric Development Technology  
310-10-60 W93-70529
- GPS-Based DSN Calibration System  
310-10-61 W93-70530

- Space Systems and Navigation Technology  
310-10-63 W93-70532
- DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542

**VERY LOW FREQUENCIES**

- Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185

**VHSC (CIRCUITS)**

- Information and Communications  
586-03-00 W93-70135

**VIBRATION**

- Laboratory Astrophysics  
188-44-57 W93-70203

**VIBRATION DAMPING**

- In-Space Technology Experiments  
506-74-00 W93-70104

**VIDEO DATA**

- In-Space Technology Experiments  
506-74-00 W93-70103

**VIKING MARS PROGRAM**

- Mars Atmosphere Dust Opacity  
155-04-00 W93-70163

**VISCOSITY**

- Earth Rotation and Mantle Structure  
579-36-03 W93-70460
- Electronic Materials  
674-21-08 W93-70506
- Glasses and Ceramics  
674-26-08 W93-70516

**VISCOUS FLOW**

- Hypersonic Training and Research  
505-70-00 W93-70021

**VISIBILITY**

- Optical Communications Technology Development  
310-20-67 W93-70541

**VISIBLE INFRARED SPIN SCAN RADIOMETER**

- Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274

**VISIBLE SPECTRUM**

- AVIRIS Operations  
463-75-63 W93-70364

**VISUAL AIDS**

- Oceanic Remote Sensing Library  
461-66-16 W93-70335

**VISUAL PERCEPTION**

- Behavior, Performance and Human Factors  
199-06-12 W93-70231

**VISUAL STIMULI**

- Behavior, Performance and Human Factors  
199-06-12 W93-70231

**VOLCANOES**

- Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140
- Planetary Materials: Geochronology  
152-14-40 W93-70146
- Global Assessment of Active Volcanism  
428-81-94 W93-70269
- Global Assessment of Active Volcanism  
428-81-96 W93-70270
- Studies of Volcanic SO2  
428-81-99 W93-70271
- Global Assessment of Active Volcanism  
429-81-94 W93-70285
- Global Assessment of Active Volcanism  
429-81-95 W93-70286
- Global Assessment of Active Volcanism  
429-81-96 W93-70287
- Global Assessment of Active Volcanism  
429-81-97 W93-70288
- Studies of Volcanic SO2, Theory  
429-81-99 W93-70289
- Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410
- Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411
- Evolution of Volcanic Terrains  
465-44-02 W93-70412
- Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413
- Measurement of Volcanic Gases  
465-44-05 W93-70414
- Volcanic Cloud Dispersion, Chemistry and Microphysics: An Analysis of the El Chichon Eruption  
465-44-06 W93-70415
- ASF SAR Interferometry  
665-35-01 W93-70500

**VOLCANOLOGY**

- Early Mars: Impact Basins, Crustal Dichotomy, Volcanic Resurfacing  
151-02-00 W93-70140

- Planetary Materials: Geochronology  
152-14-40 W93-70146
  - Global Assessment of Active Volcanism  
428-81-94 W93-70269
  - Global Assessment of Active Volcanism  
428-81-96 W93-70270
  - Studies of Volcanic SO2  
428-81-99 W93-70271
  - Global Assessment of Active Volcanism  
429-81-94 W93-70285
  - Global Assessment of Active Volcanism  
429-81-95 W93-70286
  - Global Assessment of Active Volcanism  
429-81-96 W93-70287
  - Global Assessment of Active Volcanism  
429-81-97 W93-70288
  - Studies of Volcanic SO2, Theory  
429-81-99 W93-70289
  - Monitoring Global Sea Level with Altimeter Transponders  
461-38-02 W93-70328
  - Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410
  - Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411
  - Measurement of Volcanic Gases  
465-44-05 W93-70414
  - Climate Modeling with Emphasis on Aerosols and Clouds  
578-11-01 W93-70422
- VORTICES**
- Controls, Guidance and Human Factors Research and Technology  
505-64-00 W93-70012
  - Flight Systems Research and Technology  
505-68-00 W93-70015
  - Convective Transport in the Solar Nebula  
452-22-91 W93-70303
- VORTICITY**
- Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452
- VOYAGER PROJECT**
- Planetary Atmospheric Composition, Structure, and History  
154-10-80 W93-70152
  - Cosmic and Heliospheric Physics  
170-10-10 W93-70176
  - Neptune Data Analysis  
889-59-00 W93-70524
- VOYAGER 2 SPACECRAFT**
- Neptune Data Analysis  
889-59-00 W93-70524
  - Neptune Data Analysis  
889-59-00 W93-70525
  - Neptune Data Analysis Program  
889-59-00 W93-70526

**W****WARNING SYSTEMS**

- Global Assessment of Active Volcanism  
428-81-96 W93-70270
- Global Assessment of Active Volcanism  
429-81-96 W93-70287

**WASTE DISPOSAL**

- Human Support Research and Technology  
506-71-00 W93-70093

**WASTE TREATMENT**

- Human Support Research and Technology  
506-71-00 W93-70093
- Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254

**WATER**

- In-Space Experiments  
506-74-00 W93-70102
- A Laboratory Investigation of the Formation, Properties and Evolution of Presolar Grains  
152-12-40 W93-70143
- Planetary Clouds Particulates and Ices  
154-30-80 W93-70155
- Mars 3-D Global Circulation Model  
154-95-80 W93-70161
- Mars Surface and Atmosphere Studies  
155-04-00 W93-70162
- Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253
- Biosphere Atmospheric Interactions  
429-81-26 W93-70279
- GEWEX Program Support  
461-50-03 W93-70331
- Forest/Climate Interactions  
462-21-00 W93-70337

ECHIVAL	Field	Experiment	in		
Desertification-Threatened Area (EFEDA)					
462-32-61			W93-70342		
Biogeochemical Cycling Research on the Oregon					
Transect					
462-43-00			W93-70344		
Visiting Scientists					
462-76-49			W93-70353		
Biogeochemical Research in Temperate Ecosystems					
463-67-00			W93-70363		
<b>WATER CIRCULATION</b>					
Climate Stability: The Role of the Hydrological Cycle					
and the Thermohaline Circulation					
578-31-14			W93-70436		
<b>WATER COLOR</b>					
Ocean Color Data System					
428-82-06			W93-70272		
IDS Science for WHOI/GSFC Eos Project:					
Biogeochemical Fluxes at the Air-Sea Interface					
429-81-80			W93-70284		
Phytoplankton Dynamics of North Pacific Ocean					
463-11-09			W93-70356		
Bio-Optical Interpretation of Ocean Color Imagery					
463-11-62			W93-70357		
Airborne Oceanographic Lidar (AOL)					
463-11-79			W93-70358		
<b>WATER IMMERSION</b>					
Regulatory Physiology (Biomedical)					
199-18-12			W93-70235		
<b>WATER MASERS</b>					
Center for Star Formation Studies					
399-20-01			W93-70260		
<b>WATER QUALITY</b>					
Environmental Health					
199-04-11			W93-70227		
<b>WATER RECLAMATION</b>					
Human Support Research and Technology					
506-71-00			W93-70093		
<b>WATER SPLITTING</b>					
In-Space Technology Experiments					
506-74-00			W93-70107		
<b>WATER TEMPERATURE</b>					
Airborne ESTAR					
461-38-01			W93-70327		
<b>WATER TREATMENT</b>					
In-Space Experiments					
506-74-00			W93-70102		
<b>WATER VAPOR</b>					
IR Remote Sensing of SST					
460-21-28			W93-70310		
NDSC Microwave Instrument Support					
464-13-22			W93-70372		
Lower Stratosphere Aircraft Data Analysis					
464-34-00			W93-70384		
Remote Sensing of Air-Sea Fluxes					
578-12-19			W93-70426		
Astrometric Development Technology					
310-10-60			W93-70529		
<b>WATER WAVES</b>					
Altimeter Measurements of Wind Speed and Sea Level					
Height With Applications to Air-Sea Interaction Studies:					
Physical Principles and Advanced Techniques					
461-33-02			W93-70325		
<b>WAVE PACKETS</b>					
Aerodynamics Research and Technology					
505-59-00			W93-70003		
<b>WAVE PROPAGATION</b>					
Aerodynamics Research and Technology					
505-59-00			W93-70003		
Ground-Based Support of Solar Physics					
170-38-52			W93-70179		
Theory, Laboratory and Data Analysis for Solar					
Physics					
170-38-53			W93-70180		
Origins of Solar Systems					
452-23-94			W93-70305		
<b>WAVEFORMS</b>					
Planetary Orbital/Flyby Laser Altimeter					
157-03-80			W93-70172		
Retracking of Topex Waveform Data					
461-34-01			W93-70326		
<b>WAVEGUIDE ANTENNAS</b>					
Advanced Transmitter Systems Development					
310-20-64			W93-70538		
Antenna Systems Development					
310-20-65			W93-70539		
Radio Systems Development					
310-20-66			W93-70540		
DSS 13 Instrumentation and Capabilities					
310-30-69			W93-70542		
<b>WAVELENGTHS</b>					
Theory and Modeling: Infrared, Submillimeter, and					
Radio					
188-44-53			W93-70200		
Geological Interpretation of Magsat Anomaly Data					
465-32-06			W93-70405		
<b>WEAR</b>					
Materials and Structures Research and Technology					
506-43-00			W93-70073		
<b>WEATHER</b>					
Micro Weather Stations for Mars					
157-04-80			W93-70174		
Satellite Radar for Forest Structure					
462-41-61			W93-70343		
Modeling and Data Analysis, Physical Climate and					
Hydrological Systems, Data Analysis					
578-10-00			W93-70421		
Meteorological Parameters Extraction					
578-12-20			W93-70427		
ERS-1 Studies of Forest Ecosystems					
579-41-08			W93-70466		
<b>WEATHER FORECASTING</b>					
Planetary Data System					
155-20-00			W93-70165		
Multidimensional Studies of Tropospheric Clouds					
460-47-00			W93-70316		
Scatterometer Studies					
461-31-13			W93-70324		
Meteorological Parameters Extraction					
578-12-20			W93-70427		
Tropical Ocean Circulation from Altimetry and Numerical					
Modeling					
578-21-12			W93-70430		
Studies of Sea Surface Temperature and Topography					
578-22-25			W93-70432		
Large Scale Air-Sea Interactions					
578-22-26			W93-70433		
Global Monthly Mean Ocean Variability					
578-22-29			W93-70435		
<b>WEATHER STATIONS</b>					
Micro Weather Stations for Mars					
157-04-80			W93-70174		
<b>WEATHERING</b>					
Carbon Mass Balance During Soil Evolution Along					
Climate Gradients					
465-45-01			W93-70416		
<b>WEIGHTING FUNCTIONS</b>					
Modeling of the Main Magnetic Field					
579-31-02			W93-70457		
<b>WEIGHTLESSNESS</b>					
Information and Controls Research and Technology					
506-59-00			W93-70087		
In-Space Experiments					
506-74-00			W93-70105		
Microgravity Nucleation and Particle Coagulation					
Experiments					
152-20-01			W93-70148		
Optical Technology for Space Astronomy					
188-41-23			W93-70186		
Longitudinal Studies (Medical Operations Longitudinal					
Studies)					
199-02-31			W93-70224		
General Biomedical: Center and Headquarters Support					
199-08-11			W93-70232		
Neuroscience (Biomedical)					
199-16-12			W93-70234		
Bone Mineral Metabolism and Muscle Physiology					
199-26-11			W93-70236		
Musculoskeletal (Biomedical)					
199-26-12			W93-70237		
Cell and Development Biology					
199-40-21			W93-70239		
Flight Research					
199-40-62			W93-70243		
Biotechnology					
674-23-08			W93-70509		
<b>WEIGHTLESSNESS SIMULATION</b>					
General Biomedical: Center and Headquarters Support					
199-08-11			W93-70232		
Regulatory Physiology (Biomedical)					
199-18-12			W93-70235		
Musculoskeletal (Biomedical)					
199-26-12			W93-70237		
Cell and Developmental Biology					
199-40-22			W93-70240		
Ground Experiment Operations					
674-28-05			W93-70518		
<b>WEST GERMANY</b>					
Stratospheric Observatory for Infrared Astronomy					
(SOFIA)					
188-78-60			W93-70216		
<b>WETLANDS</b>					
Biospheric/Atmospheric Interactions					
463-67-00			W93-70362		
ERS-1 SAR Investigations of Methane Emissions from					
High Latitude Ecosystems					
665-35-00			W93-70499		
<b>WIND (METEOROLOGY)</b>					
Science Sensing (Remote)					
582-03-00			W93-70110		
Science Sensing (Remote)					
582-03-00			W93-70113		
Volcanic Cloud Dispersion, Chemistry and Microphysics:					
An Analysis of the El Chichon Eruption					
465-44-06			W93-70415		
<b>WIND DIRECTION</b>					
Scatterometer Studies					
461-31-13			W93-70324		
Global Monthly Mean Ocean Variability					
578-22-29			W93-70435		
<b>WIND EFFECTS</b>					
Solar System Studies					
151-01-60			W93-70138		
<b>WIND MEASUREMENT</b>					
Science Sensing (Remote)					
582-03-00			W93-70113		
Mars 94 Winds					
155-20-04			W93-70168		
CO2 Lidar Backscatter Experiment					
460-21-00			W93-70309		
Atmospheric Backscatter Experiment					
460-22-53			W93-70313		
Wind Measurement Assessment					
460-28-41			W93-70314		
Scatterometer Research					
461-31-09			W93-70323		
Large Scale Air-Sea Interactions					
578-22-26			W93-70433		
Neptune Data Analysis					
889-59-00			W93-70524		
<b>WIND PROFILES</b>					
Science Sensing (Remote)					
582-03-00			W93-70113		
IDS Science for WHOI/GSFC Eos Project:					
Biogeochemical Fluxes at the Air-Sea Interface					
429-81-80			W93-70284		
Wind Measurement Assessment					
460-28-41			W93-70314		
<b>WIND SHEAR</b>					
Controls, Guidance and Human Factors Research and					
Technology					
505-64-00			W93-70011		
ERS-1 SAR Investigation of Ice Kinematics and Surface					
Wind Fields in the Weddell Sea					
665-35-10			W93-70502		
<b>WIND TUNNEL TESTS</b>					
Aerodynamics Research and Technology					
505-59-00			W93-70002		
Propulsion and Power					
505-62-00			W93-70005		
Systems Analysis					
505-69-00			W93-70016		
Advanced Turboprop Systems					
535-03-00			W93-70044		
Advanced Turboprop Systems					
535-03-00			W93-70045		
Emissions and Source Noise					
537-02-00			W93-70054		
<b>WIND TUNNELS</b>					
Applied Aerodynamics Research and Technology					
505-59-00			W93-70001		
High Performance Flight Research					
533-02-00			W93-70042		
High-Performance Flight Research					
533-02-00			W93-70043		
Community Noise and Sonic Boom					
537-03-00			W93-70056		
Aerothermodynamics Research and Technology					
506-40-00			W93-70063		
<b>WIND VELOCITY</b>					
Science Sensing (Remote)					
582-03-00			W93-70113		
CO2 Lidar Backscatter Experiment					
460-21-00			W93-70309		
IR Remote Sensing of SST					
460-21-28			W93-70310		
Scatterometer Research					
461-31-09			W93-70323		
Altimeter Measurements of Wind Speed and Sea Level					
Height With Applications to Air-Sea Interaction Studies:					
Physical Principles and Advanced Techniques					
461-33-02			W93-70325		
Global Monthly Mean Ocean Variability					
578-22-29			W93-70435		
ERS-1 SAR Investigation of Ice Kinematics and Surface					
Wind Fields in the Weddell Sea					
665-35-10			W93-70502		
Neptune Data Analysis Program					
889-59-00			W93-70526		
<b>WINDS ALOFT</b>					
Volcanic Cloud Dispersion, Chemistry and Microphysics:					
An Analysis of the El Chichon Eruption					
465-44-06			W93-70415		
<b>WINDS</b>					
Advanced Composite Materials Technology					
510-02-00			W93-70038		
Advanced Rotorcraft Technology					
532-06-00			W93-70040		



**WINTER**

ERS-1 Radar Permafrost Penetration	
465-41-01	W93-70407
Stratospheric Chemical Model: Dynamics	
579-23-10	W93-70452
ERS-1 SAR Investigation of Ice Kinematics and Surface	
Wind Fields in the Weddell Sea	
665-35-10	W93-70502
<b>WORD PROCESSING</b>	
Windows on Global Change	
665-82-03	W93-70503
<b>WORK CAPACITY</b>	
Expert Systems for Automation of Operations	
310-40-47	W93-70547
<b>WORKING FLUIDS</b>	
In-Space Experiments	
506-74-00	W93-70105
<b>WORKLOADS (PSYCHOPHYSIOLOGY)</b>	
Behavior, Performance and Human Factors	
199-06-12	W93-70231
<b>WORKSTATIONS</b>	
Systems Analysis	
505-69-00	W93-70016
Numerical Aerodynamic Simulation (NAS)	
536-01-00	W93-70047
NAS Operations	
536-02-00	W93-70048
A 4D Data Assimilation for EOS Computer Support	
428-81-04	W93-70262
Global Assessment of Active Volcanism	
428-81-94	W93-70269
LTP Computer Support	
579-41-04	W93-70465
A Distributed Analysis and Visualization System for	
Model and Observational Data	
656-65-27	W93-70497
Windows on Global Change	
665-82-03	W93-70503
Planning and Scheduling Systems Technology	
310-20-36	W93-70534
Mission Operations Technology	
310-40-45	W93-70546
<b>WORMS</b>	
Space Radiation	
199-04-14	W93-70228

**X****X RAY ASTRONOMY**

Optical Technology for Space Astronomy	
188-41-23	W93-70186
High Energy Astrophysics: Data Analysis, Interpretation	
and Theoretical Studies	
188-46-01	W93-70205
X-Ray Astronomy CCD	
188-46-59	W93-70209
High Throughput X-Ray Spectroscopy	
188-46-59	W93-70210

**X RAY ASTROPHYSICS FACILITY**

Materials and Structures Research and Technology	
506-43-00	W93-70076
Observatory Systems	
582-04-00	W93-70115
Automation and Robotics	
586-02-00	W93-70131

**X RAY DETECTORS**

High Throughput X-Ray Spectroscopy	
188-46-59	W93-70210

**X RAY FLUORESCENCE**

Planetary Materials: Chemistry	
152-13-40	W93-70144

**X RAY IMAGERY**

X-Ray Astronomy CCD	
188-46-59	W93-70209

**X RAY SOURCES**

High Energy Astrophysics: Data Analysis, Interpretation	
and Theoretical Studies	
188-46-01	W93-70205
X-Ray Astronomy CCD	
188-46-59	W93-70209
High Throughput X-Ray Spectroscopy	
188-46-59	W93-70210

**X RAY SPECTRA**

Optical/UV Laboratory Astrophysics	
188-41-57	W93-70191

**X RAY SPECTROSCOPY**

Planetary Instrument Definition and Development	
157-03-50	W93-70169
High Throughput X-Ray Spectroscopy	
188-46-59	W93-70210

**X RAY TELESCOPES**

High Energy Astrophysics: Data Analysis, Interpretation	
and Theoretical Studies	
188-46-01	W93-70205

Gamma Ray Astronomy	
188-46-57	W93-70207
High Energy Astrophysics International Programs	
440-62-59	W93-70299

**X RAYS**

Information and Controls Research and Technology	
506-59-00	W93-70090
Planetary Materials: Chemistry	
152-13-40	W93-70144
Optical Technology for Space Astronomy	
188-41-23	W93-70186
Photoprocesses/Spectroscopies of Astrophysical	
Molecules and Radicals	
188-41-57	W93-70190
X-Ray Astronomy CCD	
188-46-59	W93-70209
High Throughput X-Ray Spectroscopy	
188-46-59	W93-70210
Sounding Rocket Experiments	
879-11-38	W93-70522
Proposal for a High-Energy Imaging Device (HEIDI) on	
a Balloon	
879-11-48	W93-70523

**X-29 AIRCRAFT**

High-Performance Flight Research	
533-02-00	W93-70041

**XENON CHLORIDE LASERS**

NDSC Differential Absorption Lidar	
464-13-15	W93-70371

**Y****YAG LASERS**

Planetary Orbital/Flyby Laser Altimeter	
157-03-80	W93-70172
NDSC Differential Absorption Lidar	
464-13-15	W93-70371

**Z****ZONE MELTING**

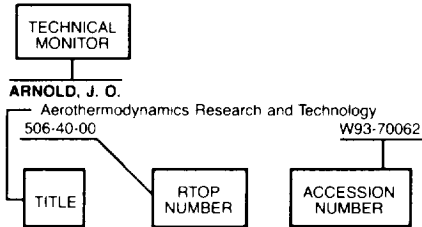
Electronic Materials	
674-21-08	W93-70506
Metals and Alloys	
674-25-05	W93-70513

# TECHNICAL MONITOR INDEX

RTOP SUMMARY

FISCAL YEAR 1993

## Typical Technical Monitor Index Listing



Listings in this index are arranged alphabetically by technical monitor. The RTOP number and accession number are included in each entry to assist the user in locating the citation and technical summary in the summary section. The titles are arranged under each technical monitor in ascending accession number order.

## A

- ABEL, PETER**  
Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project  
428-82-18 W93-70274
- ABRAMS, M. J.**  
Evolution of Volcanic Terrains  
465-44-02 W93-70412
- ABSHIRE, JAMES B.**  
Mars Lidar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies)  
157-03-90 W93-70173
- ACTON, C. H.**  
Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480
- AJELLO, J. M.**  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191
- ALBERS, J. A.**  
Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010
- ALLAMANDOLA, L. J.**  
Properties of Interstellar PAH's  
188-44-57 W93-70202
- ALLARIO, F.**  
The Nature of Interstellar Dust, Ices and Polycyclic Aromatic Hydrocarbons  
399-50-00 W93-70261
- ALLAMANDOLA, L. J.**  
Chemical Evolution of Interstellar Ices: The Connection with Primitive Solar System Materials  
452-33-93 W93-70306
- ALLARIO, F.**  
Space Flight Research and Technology  
506-48-00 W93-70079
- ALLARIO, F.**  
Science Sensing (Remote)  
582-03-00 W93-70110
- ALLARIO, F.**  
Information and Communications  
586-03-00 W93-70135
- ALLEN, J. E., JR.**  
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals  
188-41-57 W93-70190
- ARGUS, D. F.**  
Kinematic Models Combining VLBI, GPS, and Triangulation Data and Plate Constraints  
465-14-07 W93-70395
- ARNOLD, J. O.**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062
- ARNOLD, J. O.**  
Materials and Structures Research and Technology  
506-43-00 W93-70071

## B

- BAGWELL, J. W.**  
Space Communications Research and Technology  
506-72-00 W93-70096
- BAILEY, F. R.**  
Applied Aerodynamics Research and Technology  
505-59-00 W93-70001
- BALLARD, R. W.**  
Flight Research  
199-40-72 W93-70244
- BALOGA, S. M.**  
Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413
- BANKSTON, C. P.**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067
- BALOGA, S. M.**  
Surface Systems  
583-02-00 W93-70117
- BARNES, A.**  
Magnetospheric Physics - Particles and Particle/Field Interaction  
170-10-10 W93-70178
- BAUTISTA, J.**  
Radio Systems Development  
310-20-66 W93-70540
- BERGESON-WILLIS, SAM E.**  
Integral Mission Definition Study  
188-78-01 W93-70211
- BERRY, W.**  
Human Support Research and Technology  
506-71-00 W93-70093
- BIRMINGHAM, T. J.**  
Space Physics Theory Program  
431-06-00 W93-70291
- BLANKENSHIP, C. P.**  
Materials and Structures Research and Technology  
505-63-00 W93-70009
- BLANKENSHIP, C. P.**  
Advanced Composite Materials Technology  
510-02-00 W93-70038
- BLANKENSHIP, C. P.**  
Advanced Rotorcraft Technology  
532-06-00 W93-70040
- BLANKENSHIP, C. P.**  
Advanced Turboprop Systems  
535-03-00 W93-70045
- BLANKENSHIP, C. P.**  
Emissions and Source Noise  
537-02-00 W93-70055
- BLANKENSHIP, C. P.**  
Aging Aircraft  
538-02-00 W93-70061
- BLANKENSHIP, C. P.**  
Materials and Structures Research and Technology  
506-43-00 W93-70074
- BLEWITT, G.**  
GPS/VLBI Vertical Measurement  
465-14-09 W93-70396
- BLEWITT, G.**  
North American Fiducial Network  
465-14-11 W93-70397
- BOGGESE, N. W.**  
Research Computing Facility and Cataloging for Infrared  
188-44-01 W93-70192
- BOGGESE, N. W.**  
Infrared, Submillimeter, and Radio Astronomy  
188-44-23 W93-70196
- BOGGESE, N. W.**  
Theory and Modeling: Infrared, Submillimeter, and Radio  
188-44-53 W93-70200
- BORUCKI, W. J.**  
Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160
- BRANDHORST, H. W.**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70064
- BRANDHORST, H. W.**  
Surface Systems  
583-02-00 W93-70116
- BRANDHORST, H. W.**  
Earth-Orbiting Platforms  
585-03-00 W93-70124
- BRANDHORST, H. W.**  
Automation and Robotics  
586-02-00 W93-70128
- BRASS, J. A.**  
Spatial and Temporal Distribution of Biomass Combustion and Pyrogenic Trace Gas Emissions  
579-43-00 W93-70472

## BRASUNAS, J.

Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers  
157-05-50 W93-70175

## BREAZEALE, W. L.

In-Space Technology Experiments  
506-74-00 W93-70106

## BRIGGS, G.

Telepresence for Planetary Exploration  
186-06-01 W93-70182

## BUNCH, T.

Cosmic Evolution of Biogenic Compounds  
199-52-12 W93-70246

## BUSALACCHI, ANTONIO J.

Hydrophobic Processes Program Support for Modeling and Data Analysis  
578-97-12 W93-70446

## BUTLER, T. E.

Networks Communication Technology  
310-20-38 W93-70536

## C

## CAMPBELL, J. K.

Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives  
152-88-10 W93-70151

## CAPPS, R.

Astrotech 21  
188-78-44 W93-70215

## CARD, M. F.

Interdisciplinary Technology  
505-90-00 W93-70027

## CARLE, G. C.

Impact Catastrophism on the Terrestrial Planets  
196-88-01 W93-70222

Solar System Exploration  
199-52-52 W93-70249

## CARSEY, F. D.

Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282

Ice Sheet Geophysical Investigations Using Imaging Radar  
461-66-18 W93-70336

## CARSEY, F. D.

Active/Passive Sea Ice Analysis  
578-32-24 W93-70437

Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501

## CASSEN, P.

Solar System Studies  
151-01-60 W93-70138

Planet-Forming Disks  
452-21-93 W93-70302

## CASTLES, S.

Observatory Systems  
582-04-00 W93-70115

## CHACKERIAN, C., JR.

Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere  
464-23-00 W93-70380

## CHADWICK, O. A.

Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416

## CHAFFEE, N. H.

Automation and Robotics  
586-02-00 W93-70132

## CHAHINE, M. T.

Meteorological Parameters Extraction  
578-12-20 W93-70427

## CHAMIS, C. C.

Advanced Composite Materials Technology  
510-02-00 W93-70037

## CHANG, A. T. C.

Validations of Passive Microwave Snow Water Equivalent Algorithm  
461-13-00 W93-70319

## CHANG, S.

Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs  
152-13-60 W93-70145

MONITOR

Prebiotic Evolution  
199-52-22 W93-70247

**CHAPPELLE, EMMETT W.**  
Laser Induced Fluorescence: A Technique for Remote  
Assessment of Photosynthetic Efficiency and Detection  
of Environmental Stress  
462-31-63 W93-70339

**CHATFIELD, R. B.**  
Simulation of Tropospheric Ozone  
579-24-00 W93-70453

**CHOUDHURY, BHASKAR J.**  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
461-13-01 W93-70321  
Variations of Soil Moisture and Other Surface  
Parameters During HAPEX-Sahel Experiment  
462-32-03 W93-70341  
Modeling and Multispectral Satellite Data Analysis for  
Land Surface Study with Special Emphasis on Hot Arid  
and Semi-Arid Regions  
579-42-02 W93-70468

**CHRISTENSEN, E. J.**  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328

**CLARK, J. E.**  
Science Sensing (Remote)  
582-03-00 W93-70113  
Automation and Robotics  
586-02-00 W93-70131

**COHEN, E. A.**  
Millimeter and Submillimeter Spectroscopy in Support  
of Upper Atmospheric Research  
464-23-10 W93-70383

**COLLINS, D. J.**  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357

**COLLINS, S. A.**  
X-Ray Astronomy CCD  
188-46-59 W93-70209

**CONDON, E. P.**  
Atmospheric Effects  
537-01-00 W93-70049

**CONNORS, M. M.**  
Behavior, Performance and Human Factors  
199-06-12 W93-70231

**CONRATH, B. J.**  
Neptune Data Analysis  
889-59-00 W93-70524

**COOPER, D.**  
Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047  
NAS Operations  
536-02-00 W93-70048

**COOPER, LYNNE P.**  
DSN Data Processing and Productivity  
310-40-73 W93-70551

**COUCH, L. M.**  
Hypersonic Research and Technology  
505-70-00 W93-70023  
Hypersonic Research and Technology  
506-73-00 W93-70101

**CRANNELL, C. J.**  
Proposal for a High-Energy Imaging Device (HEIDI) on  
a Balloon  
879-11-48 W93-70523

**CREEDON, J. F.**  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70011  
Fly-By-Light/Power-By-Wire  
538-01-00 W93-70060  
Information and Controls Research and Technology  
506-59-00 W93-70089  
In-Space Technology Experiments  
506-74-00 W93-70104  
Earth-Orbiting Platforms  
585-03-00 W93-70125  
Automation and Robotics  
586-02-00 W93-70129  
Fluid Physics  
674-24-00 W93-70510

**CRISP, D.**  
Micro Weather Stations for Mars  
157-04-80 W93-70174  
Two-Dimensional Stratospheric Chemical Model -  
Radiation  
579-23-01 W93-70451

**CRISP, J. A.**  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
Measurement of Volcanic Gases  
465-44-05 W93-70414

**CRUIKSHANK, D. P.**  
Volatiles in the Solar System  
196-41-67 W93-70221

**CURRERI, PETER**  
Metals and Alloys  
674-25-08 W93-70514

**CUZZI, J.**  
Two-Phase Nebulae  
452-22-93 W93-70304  
Neptune Data Analysis  
889-59-00 W93-70525

## D

**DALTON, D.**  
Space Data Systems  
586-03-00 W93-70136

**DAVIDSON, JOHN M.**  
Information and Communications  
586-03-00 W93-70137

**DAVIS, C. O.**  
Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356

**DAVIS, E. S.**  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406

**DAVIS, TOM C., JR.**  
Automation and Robotics  
586-02-00 W93-70133

**DEANGELIS, V. M.**  
Materials and Structures Research and Technology  
505-63-00 W93-70006

**DEERING, DONALD W.**  
Satellite Data Sets and Algorithm Testing  
579-42-11 W93-70470

**DEJONG, E. M.**  
Solar System Visualization (SSV): Scientific Tools for  
NASA/JPL Image Archives  
656-65-06 W93-70490

**DEMORE, W. B.**  
Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379  
Data Survey and Evaluation  
464-41-04 W93-70385

**DENNIS, BRIAN R.**  
Ground-Based Support of Solar Physics  
170-38-52 W93-70179

**DESMARAI, D. J.**  
The Early Evolution of Life  
199-52-32 W93-70248

**DEVINCENZI, D. L.**  
Exploration Exobiology  
199-52-82 W93-70251

**DICK, G. JOHN**  
Frequency and Timing Research  
310-10-62 W93-70531

**DICKEY, J. O.**  
Geopotential Temporal Variations  
465-17-02 W93-70400  
Rapid Earth Orientation Changes  
579-36-10 W93-70462

**DIEHL, L. A.**  
Propulsion Research and Technology  
506-42-00 W93-70068  
Earth-to-Orbit Transportation  
584-03-00 W93-70118

**DINER, D. J.**  
Heterogeneous Scene Models  
462-61-03 W93-70347

**DORBAND, JOHN E.**  
Advanced Programs Theoretical Biology  
199-55-19 W93-70252

**DRINKWATER, M. R.**  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
ERS-1 SAR Investigation of Ice Kinematics and Surface  
Wind Fields in the Weddell Sea  
665-35-10 W93-70502

**DUECK, S. L.**  
Information Systems Newsletter  
656-50-65 W93-70477

**DUXBURY, T. C.**  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166

## E

**EAGLESON, PETER**  
Extension and Testing of the Hydrologic  
Parameterization in the GISS Atmosphere GCM  
578-11-02 W93-70423

**EINAUDI, FRANCO**  
Graduate Fellowships  
578-97-16 W93-70447

**ENGMAN, EDWIN T.**  
Desert Mesoscale/PBL  
461-13-02 W93-70322

**ETHRIDGE, EDWIN C.**  
Glasses and Ceramics  
674-26-08 W93-70516

**EVANS, D. L.**  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342

## F

**FARR, T. G.**  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407

**FERRARO, ROBERT**  
Earth and Space Sciences  
509-20-00 W93-70035

**FICHEL, CARL E.**  
Gamma Ray Astronomy  
188-46-57 W93-70207

**FISHBACH, L. H.**  
Atmospheric Effects  
537-01-00 W93-70051

**FISHER, R. R.**  
SPARTAN 201 White Light Coronagraph  
879-10-00 W93-70521

**FLASAR, F. M.**  
Dynamical Properties of Planetary Atmospheres  
154-20-80 W93-70154

**FREEMAN, A.**  
Geographical Information System for Fusion and  
Analysis of High-Resolution Remote Sensing and Ground  
Truth Data  
656-65-22 W93-70493

**FRERKING, M. A.**  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197

**FREY, HERBERT**  
Early Mars: Impact Basins, Crustal Dichotomy, Volcanic  
Resurfacing  
151-02-00 W93-70140  
Topography from SEASAT and GEOSAT Overland  
Altimetry  
579-42-03 W93-70469

**FU, L.-L.**  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431

**FULLER, GLENN C.**  
Interdisciplinary Technology  
505-90-00 W93-70025  
Interdisciplinary Technology  
506-90-00 W93-70108

**FUNG, INEZ**  
An Ocean General Circulation Model for Climate  
Studies  
578-41-43 W93-70443

## G

**GALAL, KEN**  
Flight Dynamics Technology  
310-10-26 W93-70528

**GARRISON, P. W.**  
Propulsion Research and Technology  
506-42-00 W93-70070

**GARVIN, JAMES B.**  
Planetary Orbital/Flyby Laser Altimeter  
157-03-80 W93-70172

**GARY, B. L.**  
Microwave Temperature Profiler  
464-14-20 W93-70374

**GATLIN, D. H.**  
Flight Systems Research and Technology  
505-68-00 W93-70013

**GATTI, MARK**  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542

**GIBSON, EVERETT K., JR.**  
Characteristics of Volatiles in Interplanetary Dust  
Particles  
199-52-11 W93-70245

**GIESECKE, R. L.**  
Space Flight Research and Technology  
506-48-00 W93-70081

- GLAZMAN, R. E.**  
Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques  
461-33-02 W93-70325
- GOGUEN, J. D.**  
Origins of Solar Systems  
452-23-94 W93-70305  
Neptune Data Analysis Program  
889-59-00 W93-70526
- GOLDSTEIN, M. E.**  
Interdisciplinary Technology  
505-90-00 W93-70026
- GOLDSTEIN, R.**  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177  
Solar Physics Studies  
170-38-53 W93-70181  
Magnetospheric Coupling  
432-36-00 W93-70293  
Space Physics Program Support/Detales  
433-90-00 W93-70297
- GONZALEZ-SANABRIA, O. D.**  
Space Flight Research and Technology  
506-48-00 W93-70078  
System Analysis  
506-49-00 W93-70083  
In-Space Technology Experiments  
506-74-00 W93-70103
- GOOD, J. C.**  
IPAC Astrophysics Data System (ADS) Support  
399-20-00 W93-70258
- GOODING, JAMES L.**  
Planetary Materials: Collection, Preservation and Distribution  
152-20-40 W93-70149
- GRABER, E. J.**  
Emissions and Source Noise  
537-02-00 W93-70054
- GRAY, H. R.**  
Advanced High Temperature Engine Materials  
510-01-00 W93-70036
- GREEN, M. J.**  
Hypersonics Research and Technology  
506-73-00 W93-70100
- GREEN, R. O.**  
AVIRIS Operations  
463-75-63 W93-70364  
AVIRIS Operations  
465-65-01 W93-70417
- GRIMES, J.**  
Data Interchange Standards  
656-61-03 W93-70479
- GRINDELAND, R. E.**  
Musculoskeletal (Biomedical)  
199-26-12 W93-70237
- GRISAFFE, S. J.**  
Space Transportation  
584-04-00 W93-70122
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Global Tectonic Motions  
465-14-01 W93-70394  
Core-Mantle Excitation  
579-36-11 W93-70463
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Band Structure Engineering on Silicon CCDs for Enhanced UV Response  
188-41-24 W93-70188
- GRYMES, R. A.**  
Cell and Developmental Biology  
199-40-22 W93-70240
- H**
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Mars 3-D Global Circulation Model  
154-95-80 W93-70161  
Mars Surface and Atmosphere Studies  
155-04-00 W93-70162  
Planetary Data System  
155-20-00 W93-70165
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IR Remote Sensing of SST  
460-21-28 W93-70310
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Oceanic Remote Sensing Library  
461-66-16 W93-70335  
Large Scale Air-Sea Interactions  
578-22-26 W93-70433  
Global Monthly Mean Ocean Variability  
578-22-29 W93-70435
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Deep Optical/UV Imaging of Quasars Below the Lyman Limit  
188-41-21 W93-70183
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DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases  
656-65-21 W93-70492
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Interannual Variability of Global Cycles  
429-81-06 W93-70276  
Global Climate Modeling  
578-41-01 W93-70442
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Cardiopulmonary Physiology  
199-14-12 W93-70233
- HARRIS, ROY V., JR.**  
Aerodynamics Research and Technology  
505-59-00 W93-70002  
Propulsion and Power  
505-62-00 W93-70005  
Flight Systems Research and Technology  
505-68-00 W93-70015  
Systems Analysis  
505-69-00 W93-70019  
Computational/Aeroscience  
509-10-00 W93-70031  
High-Performance Flight Research  
533-02-00 W93-70043  
Atmospheric Effects  
537-01-00 W93-70052  
Community Noise and Sonic Boom  
537-03-00 W93-70057
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Planetary Aeronomy: Theory and Analysis  
154-60-80 W93-70157  
Thermosphere-Ionosphere-Mesosphere-Magnetospheric Interactions  
432-48-00 W93-70294
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Advanced Transmitter Systems Development  
310-20-64 W93-70538
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Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429
- HAUSSLER, J. B.**  
Materials and Structures Research and Technology  
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Gravity Wave Mission Definition Study  
188-78-01 W93-70212
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NASA/IPAC Extragalactic Database  
399-20-00 W93-70259
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Advanced Search and Rescue Techniques  
669-30-10 W93-70504
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In-Space Technology Experiments  
506-74-00 W93-70107
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Controlled Ecological Life Support Systems (CELSS) Project  
199-61-11 W93-70253
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Materials and Structures Research and Technology  
505-63-00 W93-70007
- HILLMAN, JOHN J.**  
Imaging Spectropolarimeter  
157-03-70 W93-70170
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Network Signal Processing  
310-30-70 W93-70543
- HOCKENSMITH, R. P.**  
Advanced Space Systems for Users of NASA Networks  
310-20-46 W93-70537
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Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions  
370-03-00 W93-70255
- HOGE, F. E.**  
Airborne Oceanographic Lidar (AOL)  
463-11-79 W93-70358
- HOLCOMB, LEE B.**  
Computational Aerosciences  
509-10-00 W93-70028  
Earth and Space Sciences  
509-20-00 W93-70033
- HOLLAND, ALBERT W.**  
Behavior and Performance Research  
199-06-11 W93-70230
- HOLLENBACH, D. J.**  
Center for Star Formation Studies  
399-20-01 W93-70260
- HOLLIS, J. M.**  
Earth and Space Sciences  
509-20-00 W93-70034
- Center of Excellence for Space Data Information Sciences (CESDIS)  
656-65-07 W93-70491
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Theory, Laboratory and Data Analysis for Solar Physics  
170-38-53 W93-70180
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Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440
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Structural Biosystems  
199-40-42 W93-70242
- HOOK, W. R.**  
Aerothermodynamics Research and Technology  
506-40-00 W93-70063  
Systems Analysis  
506-49-00 W93-70064  
Earth-to-Orbit Transportation  
584-03-00 W93-70120  
Space Radiation Effects and Protection (Environmental Health)  
199-04-00 W93-70225  
EOS Science  
429-81-38 W93-70281  
Biospheric/Atmospheric Interactions  
463-67-00 W93-70362
- HORNER, WARD**  
Data Storage Technology  
310-40-48 W93-70548
- HURST, K.**  
Parkfield GPS Experiment  
465-13-08 W93-70393
- HUSSEY, K. J.**  
Atmospheric Parameter Mapping  
578-12-21 W93-70428
- I**
- IVINS, E. R.**  
Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
Lateral Variations in Solid Tides  
465-17-04 W93-70401
- J**
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Graphical Methods for Science Visualization and Data Analysis  
656-65-05 W93-70489
- JARVIS, C. R.**  
High-Performance Flight Research  
533-02-00 W93-70041
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Bone Mineral Metabolism and Muscle Physiology  
199-26-11 W93-70236
- JEDREY, T.**  
Space Communications Research and Technology  
506-72-00 W93-70099
- JENNINGS, DONALD E.**  
Ground-Based Infrared Astronomy  
196-41-50 W93-70218
- K**
- KAHLE, A. B.**  
Global Assessment of Active Volcanism  
429-81-97 W93-70288
- KAHN, R. A.**  
Windows on Global Change  
665-82-03 W93-70503
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Information and Controls Research and Technology  
506-59-00 W93-70091
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Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376
- KIDWELL, G. H.**  
Systems Analysis  
505-69-00 W93-70016
- KING, JOSEPH H.**  
SS Freedom Archive Planning Study  
656-61-13 W93-70483
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Ocean Color Data System  
428-82-06 W93-70272  
SeaWiFS Calibration/Validation  
463-11-01 W93-70355
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Observatory Systems  
582-04-00 W93-70114

- KLISS, M.**  
In-Space Experiments  
506-74-00 W93-70102
- KOCH, S. E.**  
A Distributed Analysis and Visualization System for  
Model and Observational Data  
656-65-27 W93-70497
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Process Studies: Radiation Dynamics and Hydrology,  
Radiation and Dynamic Processes  
460-20-00 W93-70308  
Hydrologic Processes, Field Study  
461-10-00 W93-70318  
Hydrologic Process Studies  
461-50-00 W93-70330  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Data Analysis  
578-10-00 W93-70421  
Modeling and Data Analysis, Physical Climate and  
Hydrological Systems, Modeling  
578-40-00 W93-70441  
Modeling and Data Analysis, Climate and Hydrology  
Cryosphere Studies  
578-90-00 W93-70445
- KOONTZ, S. L.**  
Materials and Structures Research and Technology  
506-43-00 W93-70077
- KRAINAK, MICHAEL A.**  
Space Communications Research and Technology  
506-72-00 W93-70098  
Optical Communications  
310-20-35 W93-70533
- KRUEGER, ARLIN J.**  
Studies of Volcanic SO<sub>2</sub>  
428-81-99 W93-70271  
Studies of Volcanic SO<sub>2</sub>, Theory  
429-81-99 W93-70289
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Submillimeter Astronomy  
188-44-23 W93-70194
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Emissions and Source Noise  
537-02-00 W93-70053  
Community Noise and Sonic Boom  
537-03-00 W93-70056
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Automated Geophysical Processor Development for the  
Alaska SAR Facility  
428-82-11 W93-70273  
Polarimetric Data Analysis  
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Sea Ice Motion in the Pacific Sector of the Arctic  
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Mapping of the Greenland Ice Sheet: A Contribution to  
the Monitoring of Global Climate  
578-35-02 W93-70439

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Multispectral Analysis of the Stratigraphic/Structural  
Record, Southwest Mexico  
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Problems in Interpreting Satellite Crustal Anomaly Field  
Data  
579-31-01 W93-70456  
Modeling of the Main Magnetic Field  
579-31-02 W93-70457
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Energetics of Interstellar Clouds  
399-20-00 W93-70257
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General Biomedical: Center and Headquarters Support  
199-08-11 W93-70232
- LAU, WILLIAM K.-M.**  
Global Hydrologic Cycle  
428-81-16 W93-70264  
Global Hydrologic Cycle  
429-81-16 W93-70278  
Biogeochemistry and Geophysics Modeling and Data  
Analysis  
579-42-01 W93-70467
- LAVERY, DAVID B.**  
Information and Controls Research and Technology  
506-59-00 W93-70087
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Science Digital Data Preservation  
656-61-07 W93-70482
- LAWLESS, J. G.**  
Airborne Science Management Operating Working  
Group Support  
462-79-00 W93-70354

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Group Support  
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Global Change  
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Concurrent Processing Testbed - Science Analysis  
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Electronic Materials  
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Optical Communications Technology Development  
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Homogeneous and Heterogeneous Processes of  
Atmospheric Interest  
464-21-05 W93-70377
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Airborne ESTAR  
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Synthetic Aperture Microwave Radiometer  
462-26-01 W93-70338
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Scatterometer Research  
461-31-09 W93-70323  
Airborne Precipitation Radar  
461-51-16 W93-70332
- LICHTEN, STEPHEN M.**  
GPS-Based DSN Calibration System  
310-10-61 W93-70530
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Astrometric Development Technology  
310-10-60 W93-70529
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Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)  
428-81-10 W93-70263  
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(Science)  
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Remote Sensing of Air-Sea Fluxes  
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Regional Carbon Flux in High Latitude Ecosystems  
463-43-00 W93-70359
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Clinical Medicine Technology Watch  
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Materials and Structures Research and Technology  
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Materials and Structures Research and Technology  
506-43-00 W93-70073
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Information and Controls Research and Technology  
506-59-00 W93-70088  
Automation and Robotics  
586-02-00 W93-70127  
Information and Communications  
586-02-00 W93-70134  
Construction of an Advanced Software Tool for Planetary  
Atmospheric Modeling  
656-65-24 W93-70494
- LUNDGREN, P. R.**  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389
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Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388

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Bioregenerative Life Support Research (CELSS)  
199-61-12 W93-70254
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Aerodynamics Research and Technology  
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Earth-Orbiting Platforms  
585-03-00 W93-70126
- MAHONEY, W. A.**  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206
- MANDL, DAN**  
Mission Operations Technology  
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- MARGITAN, J. J.**  
Ozone Measurements  
464-11-05 W93-70365

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High Throughput X-Ray Spectroscopy  
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Mars Atmosphere Dust Opacity  
155-04-00 W93-70163
- MASUOKA, EDWARD**  
LTP Visualization  
578-97-53 W93-70449  
LTP Computer Support  
579-41-04 W93-70465  
Computer and Information Systems Support  
579-82-90 W93-70474
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Biogeochemical Research in Tropical Ecosystems:  
Mechanisms of Trace Gas Production  
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Laser Laboratory Spectroscopy  
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Human Support Research and Technology  
506-71-00 W93-70095
- MCCLEESE, D. J.**  
Visiting Scientists  
462-76-49 W93-70353
- MCCORMICK, M. P.**  
Satellite Observations of Volcanic Aerosols  
465-44-00 W93-70410
- MCCREIGHT, C. R.**  
Science Sensing (Remote)  
582-03-00 W93-70109  
IR Astronomy ATD/Cryo Optical Testing and Science  
Support Activities  
188-78-44 W93-70214
- MCDERMID, I. S.**  
NDSO Differential Absorption Lidar  
464-13-15 W93-70371  
NDSO Microwave Instrument Support  
464-13-22 W93-70372
- MCGARRY, FRANK**  
Software Engineering Technology  
310-10-23 W93-70527
- MCGUIRE, R. E.**  
Space Physics Data System  
656-61-18 W93-70485  
Data Management Initiative - National Space Science  
Data Center  
656-61-21 W93-70487
- MCINTOSH, R.**  
Space Flight Research and Technology  
506-48-00 W93-70080  
In-Space Experiments  
506-74-00 W93-70105
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Planetary Materials: Mineralogy and Petrology  
152-11-40 W93-70141  
Planetary Materials: Experimental Petrology  
152-12-40 W93-70142  
Planetary Materials: Chemistry  
152-13-40 W93-70144  
Planetary Materials: Geochronology  
152-14-40 W93-70146  
Planetary Materials: Surface and Exposure Studies  
152-17-40 W93-70147  
Planetary Materials: General Operations and Laboratory  
Facilities  
152-30-40 W93-70150
- MCMAHON, S. K.**  
PDS: Data Distribution and Archive Technology  
656-61-06 W93-70481
- MEIER, D. L.**  
Simulations of Compact Radio Sources  
188-44-53 W93-70198
- MENZIES, R. T.**  
Airborne Doppler Lidar  
460-21-52 W93-70311  
Lidar Target Calibration Facility  
460-22-52 W93-70312  
Atmospheric Backscatter Experiment  
460-22-53 W93-70313  
Wind Measurement Assessment  
460-28-41 W93-70314
- MIKKELSON, D. C.**  
Systems Analysis  
505-69-00 W93-70018
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Active Deformation in the Mojave Desert and Walker  
Lane: A Global Positioning System Experiment  
465-13-06 W93-70392  
Application of Remote Sensing Imagery to Neotectonic  
Problems in the Baja California Peninsula  
465-42-06 W93-70408
- MILLER, WARNER H.**  
Communications and Telemetry  
310-20-37 W93-70535

**MOACANIN, J.**  
Materials and Structures Research and Technology  
506-43-00 W93-70075

**MOE, KAREN L.**  
Planning and Scheduling Systems Technology  
310-20-36 W93-70534

**MORRISSEY, L. A.**  
ERS-1 SAR Investigations of Methane Emissions from  
High Latitude Ecosystems  
665-35-00 W93-70499

**MOSES, J. L.**  
Earth-to-Orbit Transportation  
584-03-00 W93-70121

**MUMMA, MICHAEL J.**  
Advanced Infrared Astronomy  
196-41-54 W93-70220

## N

**NELSON, G. A.**  
Space Radiation  
199-04-14 W93-70228

**NICHOLS, LESTER D.**  
Computational Aerosciences  
509-10-00 W93-70030

**NIEDNER, MALCOLM B., JR.**  
Imaging Studies of Comets  
196-41-52 W93-70219

**NJOKU, E. G.**  
Soil/Canopy Moisture and Temperature Profiles Using  
Remote Sensing and Modeling  
579-42-13 W93-70471

**NOLL, CAREY E.**  
Crustal Dynamics Data Information System (CDDIS)  
579-32-06 W93-70459

**NUTH, J.**  
A Laboratory Investigation of the Formation, Properties  
and Evolution of Presolar Grains  
152-12-40 W93-70143

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Microgravity Nucleation and Particle Coagulation  
Experiments  
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Laboratory Astrophysics  
188-44-57 W93-70203

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Management Support: Origins of Solar Systems  
Research Program  
452-89-91 W93-70307

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Cosmic and Heliospheric Physics  
170-10-10 W93-70176

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High Energy Astrophysics: Data Analysis, Interpretation  
and Theoretical Studies  
188-46-01 W93-70205

**ORMES, J. F.**  
High Energy Astrophysics International Programs  
440-62-59 W93-70299

## P

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Longitudinal Studies (Medical Operations Longitudinal  
Studies)  
199-02-31 W93-70224

**PERIGAUD, C. M.**  
Tropical Ocean Circulation from Altimetry and Numerical  
Modeling  
578-21-12 W93-70430

**PETEET, DOROTHY**  
Paleoecological Studies of CH<sub>4</sub> Emissions  
463-43-07 W93-70360

**PETERSEN, K. L.**  
Hypersonic Research and Technology  
505-70-00 W93-70020

**PETERSON, D. L.**  
Forest/Climatic Interactions  
462-21-00 W93-70337

**PETERSON, D. L.**  
Biogeochemical Cycling Research on the Oregon  
Transect  
462-43-00 W93-70344

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Biogeochemical Research in Temperate Ecosystems  
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**PFIAFF, R. F.**  
Sounding Rockets: Space Plasma Physics  
Experiments  
435-11-00 W93-70298

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Lower Stratosphere Aircraft Data Analysis  
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Laboratory Astrophysics  
188-44-57 W93-70201

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Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370

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Global Assessment of Active Volcanism  
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Global Assessment of Active Volcanism  
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Remote Sensing of Active and Recently Active Volcanic  
Features  
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Planetary Hardcopy Preservation Task  
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Information and Controls Research and Technology  
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Science Sensing (Remote)  
582-03-00 W93-70111

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Planetary Atmospheric Composition, Structure, and  
History  
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Convective Transport in the Solar Nebula  
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Climate Modeling with Emphasis on Aerosols and  
Clouds  
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**POLLARA, FABRIZIO**  
Communication Systems Research  
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**POTTER, A. E.**  
Observations of the Moon, Mercury, and Primitive  
Asteroids  
196-41-03 W93-70217

**PREHEIM, L. E.**  
Data System Integration (Commonality and  
Interoperability)  
656-61-02 W93-70478

**PRESTON, R. A.**  
Mars 94 Winds  
155-20-04 W93-70168

**PRESTON, R. A.**  
HIPPARCOS VLBI  
399-18-00 W93-70256

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Advanced Telemetry Processing Technology  
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**PUESCHEL, R. F.**  
CO<sub>2</sub> Lidar Backscatter Experiment  
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Hypersonic Training and Research  
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## R

**RANDOLPH, J. E.**  
Solar Probe ATD  
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Multi-Sensor Balloon Measurements  
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Optical Interferometry in Space  
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Thermal Infrared Science Support  
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**RECK, GREGORY, M.**  
Systems Analysis  
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Spectral and Physical Properties of Planetary  
Atmospheric Constituents  
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Global Tropospheric Modeling of Trace Gases  
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Ground Experiment Operations  
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Retracking of Topex Waveform Data  
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the Infrared Telescope in Space  
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Systems Analysis  
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Experimental Cloud Analysis Techniques  
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Automation and Robotics  
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Stratospheric Processes and Atmospheric Chemistry  
Studies  
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Soil Moisture from SAR  
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Cell and Development Biology  
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Kinetics of Tropospheric and Stratospheric Reactions  
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Science Sensing (Remote)  
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Goldstone DOSE Support  
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**SCHOEBERL, MARK R.**  
EOS IDS, Stratospheric Temperature and Trace Gas  
Trends  
429-81-36 W93-70280

**SELLERS, PIERS J.**  
Biosphere Atmospheric Interactions  
428-81-26 W93-70265

**SELLERS, PIERS J.**  
Biosphere Atmospheric Interactions  
429-81-26 W93-70279

**SELZER, R. H.**  
Musculoskeletal  
199-26-14 W93-70238

**SENG, GARY T.**  
Fly-By-Light/Power-By-Wire Technology  
538-01-00 W93-70059

**SHAO, M.**  
Optical Stellar Interferometry  
188-41-21 W93-70184

**SHAW, B. L.**  
Controls, Guidance and Human Factors Research and  
Technology  
505-64-00 W93-70012

**SHAW, NANCY J.**  
Electronic Materials  
674-21-05 W93-70505

**SHAW, NANCY J.**  
Combustion Science  
674-22-05 W93-70507

**SHAW, NANCY J.**  
Fluid Physics  
674-24-05 W93-70511

**SHAW, NANCY J.**  
Metals and Alloys  
674-25-05 W93-70513

**SHAW, NANCY J.**  
Glasses and Ceramics  
674-26-05 W93-70515

**SHAW, NANCY J.**  
Microgravity Materials Science Laboratory (MMSL)  
674-27-05 W93-70517

**SHAW, NANCY J.**  
Ground Experiment Operations  
674-28-05 W93-70518

**SHEFFNER, E. J.**  
Landsat Land Cover Pathfinder  
579-98-00 W93-70476

**SHEPPARD, SYLVIA B.**  
Advanced Environments for Software and System  
Development  
310-40-49 W93-70549

**SINGH, H. B.**  
Global Tropospheric Experiment Aircraft,  
Measurements  
464-54-00 W93-70387

**SJOGREN, W. L.**  
Mars 94 Gravity  
155-20-03 W93-70167

**SLAVIN, JAMES A.**  
Solar Wind-Magnetosphere-Ionosphere Coupling,  
Magnetic Field Modeling, and Magnetotail Dynamics  
432-20-00 W93-70292

**SMITH, B. F.**  
Theoretical Studies of Galaxies, the Interstellar Medium,  
Molecular Clouds, Star Formation  
188-44-53 W93-70199

**SMITH, C.**  
Interdisciplinary Technology  
505-90-00 W93-70024

**SMITH, E. J.**  
Advanced Magnetometer  
465-31-01 W93-70404

**SNYDER, ROBERT S.**  
Biotechnology  
674-23-08 W93-70509

Fluid Physics  
674-24-08 W93-70512

Consulting and Program Support  
674-29-08 W93-70520

**SNYDER, W.**  
Advanced Rotorcraft Technology  
532-06-00 W93-70039

**SONNEBORN, GEORGE**  
Optical Technology for Space Astronomy  
188-41-23 W93-70186

**SPANNER, M. A.**  
Land Surface Climatology: HAPEx  
462-32-00 W93-70340

Biogeochemical Research in Temperate Ecosystems  
463-67-00 W93-70363

**SPAULDING, G. F.**  
Biotechnology Research  
674-23-01 W93-70508

**STACHNIK, R. A.**  
MM and Sub-MM Radiometry  
464-12-06 W93-70369

**STANFILL, D. F.**  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488

**STEPHENS, J. R.**  
Enabling Propulsion Materials  
537-04-00 W93-70058

**STETINA, F. L.**  
A Spatial Analysis and Modeling System for  
Environmental Management  
656-65-26 W93-70496

**STEVENS, K. G., JR.**  
Computational Aerosciences  
509-10-00 W93-70029

Earth and Space Sciences  
509-20-00 W93-70032

**STIEF, L. J.**  
Chemical Kinetics and Spectroscopy of Planetary  
Molecules and Radicals  
154-75-80 W93-70159

**STOKER, C. R.**  
Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158

**STRAND, L. D.**  
Earth-To-Orbit Transportation  
584-03-00 W93-70119

**SUNKEL, J. W.**  
Information and Controls Research and Technology  
506-59-00 W93-70092

**SURBER, FRANK**  
Systems Analysis  
506-49-00 W93-70085

**SWANSON, T. D.**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70066

**SWEIGART, A. V.**  
UV Astronomy and Data Systems  
188-41-51 W93-70189

**SWINT, M. S.**  
Space Transportation  
584-04-00 W93-70123

## T

**TAYLOR, PATRICK T.**  
Geological Interpretation of Magsat Anomaly Data  
465-32-06 W93-70405

**TEEGARDEN, BONNARD J.**  
Gamma-Ray Spectroscopy  
188-46-58 W93-70208

**TERRILE, R.**  
Astrometric Imaging Telescope  
157-03-70 W93-70171

**THIELE, OTTO W.**  
TRMM  
461-38-05 W93-70329

**THOMAS, ROGER**  
Sounding Rocket Experiments  
879-11-38 W93-70522

**THOMPSON, ANNE M.**  
EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea  
Interface  
428-81-80 W93-70268

IDS Science for WHOI/GSFC Eos Project:  
Biogeochemical Fluxes at the Air-Sea Interface  
429-81-80 W93-70284

**THORBURN, MICHAEL A.**  
Antenna Systems Development  
310-20-65 W93-70539

**THORLEY, G. W.**  
Stratospheric Observatory for Infrared Astronomy  
(SOFIA)  
188-78-60 W93-70216

**THURMAN, SAM W.**  
Space Systems and Navigation Technology  
310-10-63 W93-70532

**TOLL, DAVID**  
Subgrid Variation of Surface Parameters  
578-42-15 W93-70444

**TOON, G. C.**  
IR Solar Absorption Spectra  
464-12-05 W93-70368

**TOON, O. B.**  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155

Theoretical Investigation of Stratospheric Particulates  
579-22-00 W93-70450

**TOTH, R. A.**  
Infrared Laboratory Spectroscopy in Support of  
Stratospheric Measurements  
464-23-08 W93-70381

**TRALLI, D. M.**  
GPS Strain Monitoring in the New Madrid Seismic  
Zone  
465-13-05 W93-70391

Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399

Short-Period Tropospheric Noise in Continuous GPS  
Measurements  
465-27-02 W93-70402

**TROMBKA, JACOB I.**  
Mars Data Analysis  
155-20-00 W93-70164

Planetary Instrument Definition and Development  
157-03-50 W93-70169

**TRUSZKOWSKI, WALT**  
Human-to-Machine Interface Technology  
310-40-37 W93-70545

Expert Systems for Automation of Operations  
310-40-47 W93-70547

**TSOU, P. T.**  
Exobiology Intact Capture Technology Development  
199-52-54 W93-70250

**TUCKER, COMPTON J.**  
Foreign Visitor Support  
429-97-04 W93-70290

## V

**VALERO, F. P. J.**  
Radiative Effects in Clouds First International Satellite  
Cloud Climatology Regional Experiment  
460-42-00 W93-70315

**VANDERBILT, V. C.**  
Optical Scattering of Plant Canopies  
462-61-00 W93-70346

**VANE, D. G.**  
GEWEX Program Support  
461-50-03 W93-70331

**VANSTEENBERG, MICHAEL E.**  
NSSDC Astrophysics Data Systems Support  
656-61-17 W93-70484

**VANZYL, J. J.**  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320

Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
462-75-62 W93-70351

Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
465-68-01 W93-70420

**VENNERI, SAMUEL L.**  
Space Energy Conversion Research and Technology  
506-41-00 W93-70065

Propulsion Research and Technology  
506-42-00 W93-70069

Materials and Structures Research and Technology  
506-43-00 W93-70072

University Space Engineering Research  
506-50-00 W93-70086

Human Support Research and Technology  
506-71-00 W93-70094

Space Communications Research and Technology  
506-72-00 W93-70097

**VERNIKOS, J.**  
Regulatory Physiology (Biomedical)  
199-18-12 W93-70235

**VOORHIES, COERTE V.**  
Geomagnetic Modeling of Core Fluid Motions  
579-31-07 W93-70458

## W

**WADE, C. E.**  
Integrative Biology  
199-40-32 W93-70241

Flight Research  
199-40-62 W93-70243

**WAHLQUIST, H. D.**  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185

**WALIGORA, J. M.**  
Environmental Health  
199-04-11 W93-70227

**WALTON, A.**  
Multi-Channel Holographic Bifurcating Neural Network  
System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495

**WANNIER, P.**  
Infrared/Radio Research  
188-44-21 W93-70193

**WAY, J. B.**  
Satellite Radar for Forest Structure  
462-41-61 W93-70343

ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466

**WEBSTER, C. R.**  
Laser Diode Sensor  
464-11-07 W93-70366

**WEGENER, S.**  
Airborne IR Spectrometry  
464-12-00 W93-70367

**WEINSTOCK, K. J.**  
Image Processing Laboratory for Terrestrial Ecology  
579-41-00 W93-70464

**WELCH, R. B.**  
Neuroscience (Biomedical)  
199-16-12 W93-70234

**WESTPHAL, D. L.**  
Multidimensional Studies of Tropospheric Clouds  
460-47-00 W93-70316

**WILLIAMS, J. G.**  
Theory of Geodetic Transformations  
465-15-06 W93-70398

Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461

**WILLIAMS, LOUIS J.**  
Atmospheric Effects  
537-01-00 W93-70050

**WITTEBORN, F. C.**  
Theoretical Studies of Active Galaxies and Quasi-Stellar  
Objects (QSOs)  
188-46-01 W93-70204

Infrared Studies of Planetary Debris Around Young Main  
Sequence Stars  
452-11-93 W93-70301

**WOICESHYN, P. M.**  
Scatterometer Studies  
461-31-13 W93-70324

**WOODGATE, BRUCE E.**  
Development of UV Photon Counting Geometrically  
Stable Array Detector - Multi-Anode Microchannel Array  
(MAMA)  
188-41-24 W93-70187

**WOOLFORD, B. J.**  
Space Human Factors Behavior and Performance  
199-06-11 W93-70229

## Y

**YANG, C.**  
Radiation Health  
199-04-11 W93-70226

**YEN, C. L.**  
Interdisciplinary ATD Studies  
433-04-00 W93-70295



**YODER, C. F.**

Planetology  
151-01-70 W93-70139  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460

**YOUNG, R. E.**

Dynamics of Planetary Atmospheres  
154-20-80 W93-70153  
Volcanic Cloud Dispersion, Chemistry and Microphysics:  
An Analysis of the El Chichon Eruption  
465-44-06 W93-70415

**Z****ZEBKER, H. A.**

Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Interferometric Topography  
465-67-04 W93-70419  
ASF SAR Interferometry  
665-35-01 W93-70500

**ZIEMIANSKI, J. A.**

Propulsion and Power Research and Technology  
505-62-00 W93-70004  
Flight Systems Research and Technology  
505-68-00 W93-70014  
High Performance Flight Research  
533-02-00 W93-70042  
Advanced Turboprop Systems  
535-03-00 W93-70044  
GA/Commuter Engine Technology  
535-05-00 W93-70046

**ZLOTNICKI, V.**

Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
JPL Oceanography Group Common Computer System  
578-22-27 W93-70434

**ZUREK, R. W.**

Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Project to Interface Modeling  
429-81-72 W93-70283  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452

**ZWALLY, H. J.**

Radar-Altimeter Ice Data System  
578-97-20 W93-70448

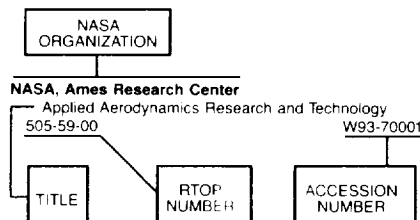


# RESPONSIBLE NASA ORGANIZATION INDEX

RTOP SUMMARY

FISCAL YEAR 1993

## Typical Responsible NASA Organization Index Listing



Listings in this index are arranged alphabetically by responsible NASA organization. The title of the RTOP provides the user with a brief description of the subject matter. The RTOP number and accession number are included in each entry to assist the user in locating the citation and technical summary in the summary section. The titles are arranged under each responsible NASA organization in ascending accession number order.

J

JPL

Aerodynamics Research and Technology  
505-59-00 W93-70003  
Earth and Space Sciences  
509-20-00 W93-70035  
Space Energy Conversion Research and Technology  
506-41-00 W93-70067  
Propulsion Research and Technology  
506-42-00 W93-70070  
Materials and Structures Research and Technology  
506-43-00 W93-70075  
Systems Analysis  
506-49-00 W93-70085  
Information and Controls Research and Technology  
506-59-00 W93-70091  
Human Support Research and Technology  
506-71-00 W93-70095  
Space Communications Research and Technology  
506-72-00 W93-70099  
Science Sensing (Remote)  
582-03-00 W93-70112  
Surface Systems  
583-02-00 W93-70117  
Earth-To-Orbit Transportation  
584-03-00 W93-70119  
Automation and Robotics  
586-02-00 W93-70130  
Information and Communications  
586-03-00 W93-70137  
Planetology  
151-01-70 W93-70139  
Study of Potential Mars Observer - Mars 94, 96 Flight  
Path Cooperatives  
152-88-10 W93-70151  
Mars Atmosphere Dust Opacity  
155-04-00 W93-70163  
U.S. Participating Scientist MARS 94/96 - Mars Global  
Geodesy  
155-20-02 W93-70166  
Mars 94 Gravity  
155-20-03 W93-70167  
Mars 94 Winds  
155-20-04 W93-70168  
Astrometric Imaging Telescope  
157-03-70 W93-70171  
Micro Weather Stations for Mars  
157-04-80 W93-70174  
Cosmic and Heliospheric Physics  
170-10-10 W93-70177

Solar Physics Studies  
170-38-53 W93-70181  
Deep Optical/UV Imaging of Quasars Below the Lyman  
Limit  
188-41-21 W93-70183  
Optical Stellar Interferometry  
188-41-21 W93-70184  
Relativity, Cosmology, and Gravitational Radiation  
188-41-22 W93-70185  
Band Structure Engineering on Silicon CCDs for  
Enhanced UV Response  
188-41-24 W93-70188  
Optical/UV Laboratory Astrophysics  
188-41-57 W93-70191  
Infrared/Radio Research  
188-44-21 W93-70193  
Submillimeter Astronomy  
188-44-23 W93-70194  
Development of 1036 GHz Receiver for Astronomy and  
Near IR Imaging at Palomar  
188-44-24 W93-70197  
Simulations of Compact Radio Sources  
188-44-53 W93-70198  
Laboratory Astrophysics  
188-44-57 W93-70201  
Gamma-Ray Astronomy and Technology Development  
188-46-57 W93-70206  
X-Ray Astronomy CCD  
188-46-59 W93-70209  
Gravity Wave Mission Definition Study  
188-78-01 W93-70212  
Optical Interferometry in Space  
188-78-41 W93-70213  
Astrotech 21  
188-78-44 W93-70215  
Space Radiation  
199-04-14 W93-70228  
Musculoskeletal  
199-26-14 W93-70238  
Exobiology Intact Capture Technology Development  
199-52-54 W93-70250  
HIPPARCOS VLBI  
399-18-00 W93-70256  
Energetics of Interstellar Clouds  
399-20-00 W93-70257  
IPAC Astrophysics Data System (ADS) Support  
399-20-00 W93-70258  
NASA/IPAC Extragalactic Database  
399-20-00 W93-70259  
Role of Air-Sea Exchanges and Ocean Circulation  
(Computing)  
428-81-10 W93-70263  
Project to Interface Modeling: EOSDIS Activities  
428-81-72 W93-70267  
Global Assessment of Active Volcanism  
428-81-94 W93-70269  
Global Assessment of Active Volcanism  
428-81-96 W93-70270  
Automated Geophysical Processor Development for the  
Alaska SAR Facility  
428-82-11 W93-70273  
Role of Air-Sea Exchanges and Ocean Circulation  
(Science)  
429-81-10 W93-70277  
Polar Exchange at the Sea Surface: JPL Component  
429-81-64 W93-70282  
Project to Interface Modeling  
429-81-72 W93-70283  
Global Assessment of Active Volcanism  
429-81-94 W93-70285  
Global Assessment of Active Volcanism  
429-81-95 W93-70286  
Global Assessment of Active Volcanism  
429-81-96 W93-70287  
Global Assessment of Active Volcanism  
429-81-97 W93-70288  
Magnetospheric Coupling  
432-36-00 W93-70293  
Interdisciplinary ATD Studies  
433-04-00 W93-70295  
Solar Probe ATD  
433-06-00 W93-70296  
Space Physics Program Support/Detailees  
433-90-00 W93-70297

Origins of Solar Systems  
452-23-94 W93-70305  
IR Remote Sensing of SST  
460-21-28 W93-70310  
Airborne Doppler Lidar  
460-21-52 W93-70311  
Lidar Target Calibration Facility  
460-22-52 W93-70312  
Atmospheric Backscatter Experiment  
460-22-53 W93-70313  
Wind Measurement Assessment  
460-28-41 W93-70314  
Measuring Soil Moisture With Imaging Radar  
461-13-00 W93-70320  
Scatterometer Research  
461-31-09 W93-70323  
Scatterometer Studies  
461-31-13 W93-70324  
Altimeter Measurements of Wind Speed and Sea Level  
Height With Applications to Air-Sea Interaction Studies:  
Physical Principles and Advanced Techniques  
461-33-02 W93-70325  
Retracking of Topex Waveform Data  
461-34-01 W93-70326  
Monitoring Global Sea Level with Altimeter  
Transponders  
461-38-02 W93-70328  
GEWEX Program Support  
461-50-03 W93-70331  
Airborne Precipitation Radar  
461-51-16 W93-70332  
Microwave Process Studies of Sea Ice Properties  
461-62-10 W93-70333  
Polarimetric Data Analysis  
461-64-11 W93-70334  
Oceanic Remote Sensing Library  
461-66-16 W93-70335  
Ice Sheet Geophysical Investigations Using Imaging  
Radar  
461-66-18 W93-70336  
ECHIVAL Field Experiment in  
Desertification-Threatened Area (EFEDA)  
462-32-61 W93-70342  
Satellite Radar for Forest Structure  
462-41-61 W93-70343  
Heterogeneous Scene Models  
462-61-03 W93-70347  
Radar Scattering Inversion: Forested Areas  
462-62-04 W93-70348  
Soil Moisture from SAR  
462-62-05 W93-70349  
Airborne Interferometric Topography  
462-74-01 W93-70350  
Airborne Synthetic Aperture Radar (AIRSAR)  
Operations  
462-75-62 W93-70351  
Thermal Infrared Science Support  
462-75-74 W93-70352  
Visiting Scientists  
462-76-49 W93-70353  
Phytoplankton Dynamics of North Pacific Ocean  
463-11-09 W93-70356  
Bio-Optical Interpretation of Ocean Color Imagery  
463-11-62 W93-70357  
AVIRIS Operations  
463-75-63 W93-70364  
Ozone Measurements  
464-11-05 W93-70365  
Laser Diode Sensor  
464-11-07 W93-70366  
IR Solar Absorption Spectra  
464-12-05 W93-70368  
MM and Sub-MM Radiometry  
464-12-06 W93-70369  
Far Infrared Balloon Radiometer for OH  
464-12-15 W93-70370  
NDSC Differential Absorption Lidar  
464-13-15 W93-70371  
NDSC Microwave Instrument Support  
464-13-22 W93-70372  
Microwave Temperature Profiler  
464-14-20 W93-70374  
Multi-Sensor Balloon Measurements  
464-16-01 W93-70375

ORGANIZATION

I-81

PRECEDING PAGE BLANK NOT FILMED

C-3

## NASA, Ames Research Center

Chemical Kinetics of the Stratosphere  
464-21-02 W93-70376  
Homogeneous and Heterogeneous Processes of Atmospheric Interest  
464-21-05 W93-70377  
Kinetics of Tropospheric and Stratospheric Reactions  
464-21-06 W93-70378  
Photochemistry of the Upper Atmosphere  
464-22-01 W93-70379  
Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements  
464-23-08 W93-70381  
Laser Laboratory Spectroscopy  
464-23-09 W93-70382  
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research  
464-23-10 W93-70383  
Data Survey and Evaluation  
464-41-04 W93-70385  
Kinetic Studies of Tropospheric Free Radicals  
464-53-01 W93-70386  
Crustal Strain Modeling Using Finite Element Methods  
465-12-03 W93-70388  
Modeling of Convergent Plate Margin Deformation  
465-12-06 W93-70389  
Dynamics of North American-Pacific Shear  
465-13-02 W93-70390  
GPS Strain Monitoring in the New Madrid Seismic Zone  
465-13-05 W93-70391  
Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment  
465-13-06 W93-70392  
Parkfield GPS Experiment  
465-13-08 W93-70393  
Global Tectonic Motions  
465-14-01 W93-70394  
Kinematic Models Combining VLBI, GPS, and Trilateration Data and Plate Constraints  
465-14-07 W93-70395  
GPS/VLBI Vertical Measurement  
465-14-09 W93-70396  
North American Fiducial Network  
465-14-11 W93-70397  
Theory of Geodetic Transformations  
465-15-06 W93-70398  
Upper Mantle Seismic P and S Wave Study  
465-16-01 W93-70399  
Geopotential Temporal Variations  
465-17-02 W93-70400  
Lateral Variations in Solid Tides  
465-17-04 W93-70401  
Short-Period Tropospheric Noise in Continuous GPS Measurements  
465-27-02 W93-70402  
Goldstone DOSE Support  
465-28-02 W93-70403  
Advanced Magnetometer  
465-31-01 W93-70404  
ARISTOTELES GPS Receiver Development  
465-35-05 W93-70406  
ERS-1 Radar Permafrost Penetration  
465-41-01 W93-70407  
Application of Remote Sensing Imagery to Neotectonic Problems in the Baja California Peninsula  
465-42-06 W93-70408  
Multispectral Analysis of the Stratigraphic/Structural Record, Southwest Mexico  
465-43-03 W93-70409  
Remote Sensing of Active and Recently Active Volcanic Features  
465-44-01 W93-70411  
Evolution of Volcanic Terrains  
465-44-02 W93-70412  
Validation of Volcanic Plume Models with Remote Sensing  
465-44-04 W93-70413  
Measurement of Volcanic Gases  
465-44-05 W93-70414  
Carbon Mass Balance During Soil Evolution Along Climate Gradients  
465-45-01 W93-70416  
AVIRIS Operations  
465-65-01 W93-70417  
Airborne Interferometric Topography  
465-67-04 W93-70419  
Airborne Synthetic Aperture Radar (AIRSAR) Operations  
465-68-01 W93-70420  
Remote Sensing of Air-Sea Fluxes  
578-12-19 W93-70426  
Meteorological Parameters Extraction  
578-12-20 W93-70427  
Atmospheric Parameter Mapping  
578-12-21 W93-70428

Outgoing Spectral Radiance: A Climate Diagnostic  
578-12-59 W93-70429  
Tropical Ocean Circulation from Altimetry and Numerical Modeling  
578-21-12 W93-70430  
Ocean Circulation from Satellite Altimetry  
578-22-24 W93-70431  
Studies of Sea Surface Temperature and Topography  
578-22-25 W93-70432  
Large Scale Air-Sea Interactions  
578-22-26 W93-70433  
JPL Oceanography Group Common Computer System  
578-22-27 W93-70434  
Global Monthly Mean Ocean Variability  
578-22-29 W93-70435  
Active/Passive Sea Ice Analysis  
578-32-24 W93-70437  
Sea Ice Motion in the Pacific Sector of the Arctic  
578-35-01 W93-70438  
Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate  
578-35-02 W93-70439  
Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR  
578-35-04 W93-70440  
Two-Dimensional Stratospheric Chemical Model - Radiation  
579-23-01 W93-70451  
Stratospheric Chemical Model: Dynamics  
579-23-10 W93-70452  
Earth Rotation and Mantle Structure  
579-36-03 W93-70460  
Geophysical Analysis and Modeling of LLR Data  
579-36-09 W93-70461  
Rapid Earth Orientation Changes  
579-36-10 W93-70462  
Core-Mantle Excitation  
579-36-11 W93-70463  
ERS-1 Studies of Forest Ecosystems  
579-41-08 W93-70466  
Soil/Canopy Moisture and Temperature Profiles Using Remote Sensing and Modeling  
579-42-13 W93-70471  
Information Systems Newsletter  
656-50-65 W93-70477  
Data System Integration (Commonality and Interoperability)  
656-61-02 W93-70478  
Data Interchange Standards  
656-61-03 W93-70479  
Navigation Ancillary Information Facility (NAIF)  
656-61-05 W93-70480  
PDS: Data Distribution and Archive Technology  
656-61-06 W93-70481  
Science Digital Data Preservation  
656-61-07 W93-70482  
Planetary Hardcopy Preservation Task  
656-61-20 W93-70486  
Image Animation Laboratory for Science Visualization  
656-65-04 W93-70488  
Graphical Methods for Science Visualization and Data Analysis  
656-65-05 W93-70489  
Solar System Visualization (SSV): Scientific Tools for NASA/JPL Image Archives  
656-65-06 W93-70490  
DataHub - Knowledge-Based Assistance for Science Visualization and Analysis Using Large Distributed Databases  
656-65-21 W93-70492  
Geographical Information System for Fusion and Analysis of High-Resolution Remote Sensing and Ground Truth Data  
656-65-22 W93-70493  
Multi-Channel Holographic Bifurcating Neural Network System for Real-Time Adaptive EOS Data Analysis  
656-65-25 W93-70495  
Concurrent Processing Testbed - Science Analysis  
656-74-03 W93-70498  
ASF SAR Interferometry  
665-35-01 W93-70500  
Estimation of Greenland Sea Brine and Freshwater Fluxes from ERS-1 and SSM/I Data  
665-35-09 W93-70501  
ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea  
665-35-10 W93-70502  
Windows on Global Change  
665-82-03 W93-70503  
Neptune Data Analysis Program  
889-59-00 W93-70526  
Astrometric Development Technology  
310-10-60 W93-70529  
GPS-Based DSN Calibration System  
310-10-61 W93-70530

## RESPONSIBLE NASA ORGANIZATION INDEX

Frequency and Timing Research  
310-10-62 W93-70531  
Space Systems and Navigation Technology  
310-10-63 W93-70532  
Advanced Transmitter Systems Development  
310-20-64 W93-70538  
Antenna Systems Development  
310-20-65 W93-70539  
Radio Systems Development  
310-20-66 W93-70540  
Optical Communications Technology Development  
310-20-67 W93-70541  
DSS 13 Instrumentation and Capabilities  
310-30-69 W93-70542  
Network Signal Processing  
310-30-70 W93-70543  
Communication Systems Research  
310-30-71 W93-70544  
DSN Data Processing and Productivity  
310-40-73 W93-70551

## N

### NASA, Ames Research Center

Applied Aerodynamics Research and Technology  
505-59-00 W93-70001  
Materials and Structures Research and Technology  
505-63-00 W93-70006  
Controls, Guidance, and Human Factors Research and Technology  
505-64-00 W93-70010  
Flight Systems Research and Technology  
505-68-00 W93-70013  
Systems Analysis  
505-69-00 W93-70016  
Hypersonic Research and Technology  
505-70-00 W93-70020  
Interdisciplinary Technology  
505-90-00 W93-70024  
Computational Aerosciences  
509-10-00 W93-70029  
Earth and Space Sciences  
509-20-00 W93-70032  
Advanced Rotorcraft Technology  
532-06-00 W93-70039  
High-Performance Flight Research  
533-02-00 W93-70041  
Numerical Aerodynamic Simulation (NAS)  
536-01-00 W93-70047  
NAS Operations  
536-02-00 W93-70048  
Atmospheric Effects  
537-01-00 W93-70049  
Emissions and Source Noise  
537-02-00 W93-70053  
Community Noise and Sonic Boom  
537-03-00 W93-70056  
Aerothermodynamics Research and Technology  
506-40-00 W93-70062  
Materials and Structures Research and Technology  
506-43-00 W93-70071  
Information and Controls Research and Technology  
506-59-00 W93-70088  
Human Support Research and Technology  
506-71-00 W93-70093  
Hypersonics Research and Technology  
506-73-00 W93-70100  
In-Space Experiments  
506-74-00 W93-70102  
Science Sensing (Remote)  
582-03-00 W93-70109  
Observatory Systems  
582-04-00 W93-70114  
Automation and Robotics  
586-02-00 W93-70127  
Information and Communications  
586-02-00 W93-70134  
Solar System Studies  
151-01-60 W93-70138  
Planetary Materials - Carbonaceous Meteorites and Cometary Ice Analogs  
152-13-60 W93-70145  
Planetary Atmospheric Composition, Structure, and History  
154-10-80 W93-70152  
Dynamics of Planetary Atmospheres  
154-20-80 W93-70153  
Planetary Clouds Particulates and Ices  
154-30-80 W93-70155  
Studies of Cloud Processes on the Outer Planets  
154-60-80 W93-70158  
Planetary Lightning and Analysis of Voyager Observations  
154-90-80 W93-70160

Mars 3-D Global Circulation Model	W93-70161	Land Surface Climatology: HAPEX	W93-70340	Space Flight Research and Technology	W93-70080
154-95-80		462-32-00		506-48-00	
Mars Surface and Atmosphere Studies	W93-70162	Biogeochemical Cycling Research on the Oregon		Information and Controls Research and Technology	W93-70090
155-04-00		Transect	W93-70344	506-59-00	
Planetary Data System	W93-70165	462-43-00		Space Communications Research and Technology	W93-70098
155-20-00		Biogeochemical Research in Temperate Ecosystems	W93-70345	506-72-00	
Magnetospheric Physics - Particles and Particle/Field		462-43-00		In-Space Experiments	W93-70105
Interaction	W93-70178	Optical Scattering of Plant Canopies	W93-70346	506-74-00	
170-10-10		462-61-00		Science Sensing (Remote)	W93-70111
Telepresence for Planetary Exploration	W93-70182	Airborne Science Management Operating Working		582-03-00	
186-06-01		Group Support	W93-70354	Observatory Systems	W93-70115
Infrared and Radio Astrophysics Technical		462-79-00		582-04-00	
Development: Ground-Based Astronomical Instrument	W93-70195	Regional Carbon Flux in High Latitude Ecosystems	W93-70359	Space Data Systems	W93-70136
188-44-23		463-43-00		586-03-00	
Theoretical Studies of Galaxies, the Interstellar Medium,		Biogeochemical Research in Tropical Ecosystems:		Early Mars: Impact Basins, Crustal Dichotomy, Volcanic	
Molecular Clouds, Star Formation	W93-70199	Mechanisms of Trace Gas Production	W93-70361	Resurfacing	W93-70140
188-44-53		463-61-00		151-02-00	
Properties of Interstellar PAH's	W93-70202	Biogeochemical Research in Temperate Ecosystems	W93-70363	A Laboratory Investigation of the Formation, Properties	
188-44-57		463-67-00		and Evolution of Presolar Grains	W93-70143
Theoretical Studies of Active Galaxies and Quasi-Stellar		Airborne IR Spectrometry	W93-70367	152-12-40	
Objects (QSOs)	W93-70204	464-12-00		Microgravity Nucleation and Particle Coagulation	
188-46-01		Stratospheric Processes and Atmospheric Chemistry		Experiments	W93-70148
IR Astronomy ATD/Cryo Optical Testing and Science		464-14-00	W93-70373	152-20-01	
Support Activities	W93-70214	Quantitative Infrared Spectroscopy of Minor		Dynamic Properties of Planetary Atmospheres	W93-70154
188-78-44		Constituents of the Earth's Stratosphere	W93-70380	154-20-80	
Stratospheric Observatory for Infrared Astronomy		464-23-00		Spectral and Physical Properties of Planetary	
(SOFIA)	W93-70216	Lower Stratosphere Aircraft Data Analysis	W93-70384	Atmospheric Constituents	W93-70156
188-78-60		464-34-00		154-50-80	
Volatiles in the Solar System	W93-70221	Global Tropospheric Experiment Aircraft,		Planetary Aeronomy: Theory and Analysis	W93-70157
196-41-67		Measurements	W93-70387	154-60-80	
Impact Catastrophism on the Terrestrial Planets	W93-70222	464-54-00		Chemical Kinetics and Spectroscopy of Planetary	
196-88-01		Volcanic Cloud Dispersion, Chemistry and Microphysics:		Molecules and Radicals	W93-70159
Behavior, Performance and Human Factors	W93-70231	An Analysis of the El Chichon Eruption	W93-70415	154-75-80	
199-06-12		465-44-06		Mars Data Analysis	W93-70164
Cardiopulmonary Physiology	W93-70233	Airborne Science Management Operating Working		155-20-00	
199-14-12		Group Support	W93-70418	Planetary Instrument Definition and Development	W93-70169
Neuroscience (Biomedical)	W93-70234	465-66-00		157-03-50	
199-16-12		Climate Modeling with Emphasis on Aerosols and		Imaging Spectropolarimeter	W93-70170
Regulatory Physiology (Biomedical)	W93-70235	Clouds	W93-70422	157-03-70	
199-18-12		578-11-01		Planetary Orbital/Flyby Laser Altimeter	W93-70172
Musculoskeletal (Biomedical)	W93-70237	Theoretical Investigation of Stratospheric Particulates	W93-70450	157-03-80	
199-26-12		579-22-00		Mars Lidar (Lidar from the Mars Surface and Mars Orbit	
Cell and Developmental Biology	W93-70240	Simulation of Tropospheric Ozone	W93-70453	for Atmospheric Studies)	W93-70173
199-40-22		579-24-00		157-03-90	
Integrative Biology	W93-70241	Image Processing Laboratory for Terrestrial Ecology	W93-70464	Planetary Instrument Development Program/Planetary	
199-40-32		579-41-00		Astronomy High Temperature Superconductor	
Structural Biosystems	W93-70242	Spatial and Temporal Distribution of Biomass	W93-70472	Bolometers	W93-70175
199-40-42		Combustion and Pyrogenic Trace Gas Emissions	W93-70473	157-05-50	
Flight Research	W93-70243	579-43-00		Cosmic and Heliospheric Physics	W93-70176
199-40-62		Bibliography for Land Processes Publications	W93-70475	170-10-10	
Flight Research	W93-70244	579-82-00		Ground-Based Support of Solar Physics	W93-70179
199-40-72		Global Change	W93-70476	170-38-52	
Cosmic Evolution of Biogenic Compounds	W93-70246	579-97-00		Theory, Laboratory and Data Analysis for Solar	
199-52-12		Landsat Land Cover Pathfinder	W93-70476	Physics	W93-70180
Prebiotic Evolution	W93-70247	579-98-00		170-38-53	
199-52-22		Construction of an Advanced Software Tool for Planetary		Optical Technology for Space Astronomy	W93-70186
The Early Evolution of Life	W93-70248	Atmospheric Modeling	W93-70494	188-41-23	
199-52-32		656-65-24		Development of UV Photon Counting Geometrically	
Solar System Exploration	W93-70249	ERS-1 SAR Investigations of Methane Emissions from	W93-70499	Stable Array Detector - Multi-Anode Microchannel Array	
199-52-52		High Latitude Ecosystems	W93-70525	(MAMA)	W93-70187
Exploration Exobiology	W93-70251	665-35-00		UV Astronomy and Data Systems	W93-70189
199-52-82		Neptune Data Analysis	W93-70276	188-41-51	
Bioregenerative Life Support Research (CELSS)	W93-70254	889-59-00		Photoprocesses/Spectroscopies of Astrophysical	
199-61-12		<b>NASA, Goddard Inst. for Space Studies</b>	W93-70360	Molecules and Radicals	W93-70190
Center for Star Formation Studies	W93-70260	Interannual Variability of Global Cycles	W93-70423	Research Computing Facility and Cataloging for	
399-20-01		429-81-06		Infrared	W93-70192
The Nature of Interstellar Dust, Ices and Polycyclic		Paleocological Studies of CH <sub>4</sub> Emissions	W93-70424	188-44-01	
Aromatic Hydrocarbons	W93-70261	463-43-07		Infrared, Submillimeter, and Radio Astronomy	W93-70196
399-50-00		Extension and Testing of the Hydrologic	W93-70425	188-44-23	
The Development of a Mid-Infrared Spectrometer for		Parameterization in the GISS Atmosphere GCM		Theory and Modeling: Infrared, Submillimeter, and	
the Infrared Telescope in Space	W93-70300	578-11-02		Radio	W93-70200
440-63-44		Experimental Cloud Analysis Techniques	W93-70436	188-44-53	
Infrared Studies of Planetary Debris Around Young Main	W93-70301	578-12-01		Laboratory Astrophysics	W93-70203
Sequence Stars	W93-70302	An Integrated Study of Surface Property Variations	W93-70442	188-44-57	
452-11-93		578-12-02		High Energy Astrophysics: Data Analysis, Interpretation	
Planet-Forming Disks	W93-70303	Climate Stability: The Role of the Hydrological Cycle	W93-70443	and Theoretical Studies	W93-70205
452-21-93		and the Thermohaline Circulation	W93-70454	188-46-01	
Convective Transport in the Solar Nebula	W93-70304	578-31-14		Gamma Ray Astronomy	W93-70207
452-22-91		Global Climate Modeling	W93-70455	188-46-57	
Two-Phase Nebulae	W93-70306	578-41-01		Gamma-Ray Spectroscopy	W93-70210
452-22-93		An Ocean General Circulation Model for Climate		High Throughput X-Ray Spectroscopy	W93-70211
Chemical Evolution of Interstellar Ices: The Connection		Studies		188-46-59	
with Primitive Solar System Materials	W93-70309	578-41-43		Integral Mission Definition Study	W93-70218
452-33-93		Global Tropospheric Modeling of Trace Gases		188-78-01	
CO <sub>2</sub> Lidar Backscatter Experiment	W93-70315	579-24-06		Ground-Based Infrared Astronomy	W93-70219
460-21-00		Climatological Stratospheric Modeling		Imaging Studies of Comets	W93-70220
Radiative Effects in Clouds First International Satellite	W93-70316	579-24-09		Advanced Infrared Astronomy	W93-70222
Cloud Climatology Regional Experiment	W93-70317	<b>NASA, Goddard Space Flight Center</b>		Advanced Programs Theoretical Biology	W93-70252
460-42-00		Controls, Guidance and Human Factors Research and		199-55-19	
Multidimensional Studies of Tropospheric Clouds		Technology			
460-47-00		505-64-00			
Earth Science Advanced Aircraft (ESAA)	W93-70317	Earth and Space Sciences			
460-97-00		509-20-00			
Forest/Climate Interactions	W93-70337	Space Energy Conversion Research and Technology			
462-21-00		506-41-00			

Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions W93-70255  
 370-03-00 A 4D Data Assimilation for EOS Computer Support W93-70262  
 428-81-04 Global Hydrologic Cycle W93-70264  
 428-81-16 Biosphere Atmospheric Interactions W93-70265  
 428-81-26 EOS IDS, EOSDIS Money W93-70266  
 428-81-36 EOS DIS for IDS on Biogeochemical Fluxes at Air/Sea Interface W93-70268  
 428-81-80 Studies of Volcanic SO<sub>2</sub> W93-70271  
 428-81-99 Ocean Color Data System W93-70272  
 428-82-06 Remote Measurement of the Gain of Satellite Radiometers: The NASA Aircraft Satellite Instrument Calibration (NASIC) Project W93-70274  
 428-82-18 4D Data Assimilation for EOS W93-70275  
 429-81-04 Global Hydrologic Cycle W93-70278  
 429-81-16 Biosphere Atmospheric Interactions W93-70279  
 429-81-26 EOS IDS, Stratospheric Temperature and Trace Gas Trends W93-70280  
 429-81-36 IDS Science for WHOI/GSFC Eos Project: Biogeochemical Fluxes at the Air-Sea Interface W93-70284  
 429-81-80 Studies of Volcanic SO<sub>2</sub>, Theory W93-70289  
 429-81-99 Foreign Visitor Support W93-70290  
 429-97-04 Space Physics Theory Program W93-70291  
 431-06-00 Solar Wind-Magnetosphere-Ionosphere Coupling, Magnetic Field Modeling, and Magnetotail Dynamics W93-70292  
 432-20-00 Thermosphere-Ionosphere-Mesosphere-Magnetosphere Interactions W93-70294  
 432-48-00 Sounding Rockets: Space Plasma Physics Experiments W93-70298  
 435-11-00 High Energy Astrophysics International Programs W93-70299  
 440-62-59 Management Support: Origins of Solar Systems Research Program W93-70307  
 452-89-91 Validations of Passive Microwave Snow Water Equivalent Algorithm W93-70319  
 461-13-00 Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions W93-70321  
 461-13-01 Desert Mesoscale/PBL W93-70322  
 461-13-02 Airborne ESTAR W93-70327  
 461-38-01 TRMM W93-70329  
 461-38-05 Synthetic Aperture Microwave Radiometer W93-70338  
 462-26-01 Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress W93-70339  
 462-31-63 Variations of Soil Moisture and Other Surface Parameters During HAPEX-Sahel Experiment W93-70341  
 462-32-03 SeaWiFS Calibration/Validation W93-70355  
 463-11-01 Geological Interpretation of Magsat Anomaly Data W93-70405  
 465-32-06 Subgrid Variation of Surface Parameters W93-70444  
 578-42-15 Hydrospheric Processes Program Support for Modeling and Data Analysis W93-70446  
 578-97-12 Graduate Fellowships W93-70447  
 578-97-16 Radar-Altimeter Ice Data System W93-70448  
 578-97-20 LTP Visualization W93-70449  
 578-97-53 Problems in Interpreting Satellite Crustal Anomaly Field Data W93-70456  
 579-31-01 Modeling of the Main Magnetic Field W93-70457  
 579-31-02

Geomagnetic Modeling of Core Fluid Motions W93-70458  
 579-31-07 Crustal Dynamics Data Information System (CDDIS) W93-70459  
 579-32-06 LTP Computer Support W93-70465  
 579-41-04 Biogeochemistry and Geophysics Modeling and Data Analysis W93-70467  
 579-42-01 Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions W93-70468  
 579-42-02 Topography from SEASAT and GEOSAT Overland Altimetry W93-70469  
 579-42-03 Satellite Data Sets and Algorithm Testing W93-70470  
 579-42-11 Computer and Information Systems Support W93-70474  
 579-82-90 SS Freedom Archive Planning Study W93-70483  
 656-61-13 NSSDC Astrophysics Data Systems Support W93-70484  
 656-61-17 Space Physics Data System W93-70485  
 656-61-18 Data Management Initiative - National Space Science Data Center W93-70487  
 656-61-21 Center of Excellence for Space Data Information Sciences (CESDIS) W93-70491  
 656-65-07 A Spatial Analysis and Modeling System for Environmental Management W93-70496  
 656-65-26 A Distributed Analysis and Visualization System for Model and Observational Data W93-70497  
 656-65-27 Advanced Search and Rescue Techniques W93-70504  
 669-30-10 SPARTAN 201 White Light Coronagraph W93-70521  
 879-10-00 Sounding Rocket Experiments W93-70522  
 879-11-38 Proposal for a High-Energy Imaging Device (HEIDI) on a Balloon W93-70523  
 879-11-48 Neptune Data Analysis W93-70524  
 889-59-00 Software Engineering Technology W93-70527  
 310-10-23 Flight Dynamics Technology W93-70528  
 310-10-26 Optical Communications W93-70533  
 310-20-35 Planning and Scheduling Systems Technology W93-70534  
 310-20-36 Communications and Telemetry W93-70535  
 310-20-37 Networks Communication Technology W93-70536  
 310-20-38 Advanced Space Systems for Users of NASA Networks W93-70537  
 310-20-46 Human-to-Machine Interface Technology W93-70545  
 310-40-37 Mission Operations Technology W93-70546  
 310-40-45 Expert Systems for Automation of Operations W93-70547  
 310-40-47 Data Storage Technology W93-70548  
 310-40-48 Advanced Environments for Software and System Development W93-70549  
 310-40-49 Advanced Telemetry Processing Technology W93-70550  
 310-40-51  
**NASA, Johnson Space Center**  
 Materials and Structures Research and Technology W93-70077  
 506-43-00 Space Flight Research and Technology W93-70081  
 506-48-00 Information and Controls Research and Technology W93-70092  
 506-59-00 In-Space Technology Experiments W93-70107  
 506-74-00 Automation and Robotics W93-70132  
 586-02-00 Planetary Materials: Mineralogy and Petrology W93-70141  
 152-11-40 Planetary Materials: Experimental Petrology W93-70142  
 152-12-40 Planetary Materials: Chemistry W93-70144  
 152-13-40 Planetary Materials: Geochronology W93-70146  
 152-14-40

Planetary Materials: Surface and Exposure Studies W93-70147  
 152-17-40 Planetary Materials: Collection, Preservation and Distribution W93-70149  
 152-20-40 Planetary Materials: General Operations and Laboratory Facilities W93-70150  
 152-30-40 Observations of the Moon, Mercury, and Primitive Asteroids W93-70217  
 196-41-03 Clinical Medicine Technology Watch W93-70223  
 199-02-31 Longitudinal Studies (Medical Operations Longitudinal Studies) W93-70224  
 199-02-31 Radiation Health W93-70226  
 199-04-11 Environmental Health W93-70227  
 199-04-11 Space Human Factors Behavior and Performance W93-70229  
 199-06-11 Behavior and Performance Research W93-70230  
 199-06-11 General Biomedical: Center and Headquarters Support W93-70232  
 199-08-11 Bone Mineral Metabolism and Muscle Physiology W93-70236  
 199-26-11 Cell and Development Biology W93-70239  
 199-40-21 Characteristics of Volatiles in Interplanetary Dust Particles W93-70245  
 199-52-11 Controlled Ecological Life Support Systems (CELSS) Project W93-70253  
 199-61-11 Biotechnology Research W93-70508  
 674-23-01  
**NASA, Kennedy Space Center**  
 Automation and Robotics W93-70133  
 586-02-00  
**NASA, Langley Research Center**  
 Aerodynamics Research and Technology W93-70002  
 505-59-00 Propulsion and Power W93-70005  
 505-62-00 Materials and Structures Research and Technology W93-70009  
 505-63-00 Controls, Guidance and Human Factors Research and Technology W93-70011  
 505-64-00 Flight Systems Research and Technology W93-70015  
 505-68-00 Systems Analysis W93-70019  
 505-69-00 Hypersonic Research and Technology W93-70023  
 505-70-00 Interdisciplinary Technology W93-70027  
 505-90-00 Computational/Aeroscience W93-70031  
 509-10-00 Advanced Composite Materials Technology W93-70038  
 510-02-00 Advanced Rotorcraft Technology W93-70040  
 532-06-00 High-Performance Flight Research W93-70043  
 533-02-00 Advanced Turboprop Systems W93-70045  
 535-03-00 Atmospheric Effects W93-70052  
 537-01-00 Emissions and Source Noise W93-70055  
 537-02-00 Community Noise and Sonic Boom W93-70057  
 537-03-00 Fly-By-Light/Power-By-Wire W93-70060  
 538-01-00 Aging Aircraft W93-70061  
 538-02-00 Aerothermodynamics Research and Technology W93-70063  
 506-40-00 Materials and Structures Research and Technology W93-70074  
 506-43-00 Space Flight Research and Technology W93-70079  
 506-48-00 Systems Analysis W93-70084  
 506-49-00 Information and Controls Research and Technology W93-70089  
 506-59-00 Hypersonic Research and Technology W93-70101  
 506-73-00 In-Space Technology Experiments W93-70104  
 506-74-00 Science Sensing (Remote) W93-70110  
 582-03-00

Earth-to-Orbit Transportation	W93-70120	Science Sensing (Remote)	W93-70113
584-03-00		582-03-00	
Earth-Orbiting Platforms	W93-70125	Earth-to-Orbit Transportation	W93-70121
585-03-00		584-03-00	
Automation and Robotics	W93-70129	Space Transportation	W93-70123
586-02-00		584-04-00	
Information and Communications	W93-70135	Earth-Orbiting Platforms	W93-70126
586-03-00		585-03-00	
Space Radiation Effects and Protection (Environmental Health)	W93-70225	Automation and Robotics	W93-70131
199-04-00		586-02-00	
EOS Science	W93-70281	Process Studies: Radiation Dynamics and Hydrology, Radiation and Dynamic Processes	W93-70308
429-81-38		460-20-00	
Biospheric/Atmospheric Interactions	W93-70362	Hydrologic Processes, Field Study	W93-70318
463-67-00		461-10-00	
Satellite Observations of Volcanic Aerosols	W93-70410	Hydrologic Process Studies	W93-70330
465-44-00		461-50-00	
Fluid Physics	W93-70510	Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis	W93-70421
674-24-00		578-10-00	
<b>NASA, Lewis Research Center</b>		Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling	W93-70441
Propulsion and Power Research and Technology	W93-70004	578-40-00	
505-62-00		Modeling and Data Analysis, Climate and Hydrology	W93-70445
Materials and Structures Research and Technology	W93-70008	Cryosphere Studies	W93-70506
505-63-00		578-90-00	
Flight Systems Research and Technology	W93-70014	Electronic Materials	W93-70509
505-68-00		674-21-08	
Systems Analysis	W93-70018	Biotechnology	W93-70512
505-69-00		674-23-08	
Hypersonic Research and Technology	W93-70022	Fluid Physics	W93-70514
505-70-00		674-24-08	
Interdisciplinary Technology	W93-70026	Metals and Alloys	W93-70516
505-90-00		674-25-08	
Computational Aerosciences	W93-70030	Glasses and Ceramics	W93-70519
509-10-00		674-26-08	
Advanced High Temperature Engine Materials	W93-70036	Ground Experiment Operations	W93-70520
510-01-00		674-28-08	
Advanced Composite Materials Technology	W93-70037	Consulting and Program Support	
510-02-00		674-29-08	
High Performance Flight Research	W93-70042	<b>NASA, Wallops Flight Flight Facility</b>	
533-02-00		Airborne Oceanographic Lidar (AOL)	W93-70358
Advanced Turboprop Systems	W93-70044	463-11-79	
535-03-00		<b>NASA, Washington</b>	
GA/Commuter Engine Technology	W93-70046	Materials and Structures Research and Technology	W93-70007
535-05-00		505-63-00	
Atmospheric Effects	W93-70051	Systems Analysis	W93-70017
537-01-00		505-69-00	
Emissions and Source Noise	W93-70054	Hypersonic Training and Research	W93-70021
537-02-00		505-70-00	
Enabling Propulsion Materials	W93-70058	Interdisciplinary Technology	W93-70025
537-04-00		505-90-00	
Fly-By-Light/Power-By-Wire Technology	W93-70059	Computational Aerosciences	W93-70028
538-01-00		509-10-00	
Space Energy Conversion Research and Technology	W93-70064	Earth and Space Sciences	W93-70033
506-41-00		509-20-00	
Propulsion Research and Technology	W93-70068	Atmospheric Effects	W93-70050
506-42-00		537-01-00	
Materials and Structures Research and Technology	W93-70073	Space Energy Conversion Research and Technology	W93-70065
506-43-00		506-41-00	
Space Flight Research and Technology	W93-70078	Propulsion Research and Technology	W93-70069
506-48-00		506-42-00	
System Analysis	W93-70083	Materials and Structures Research and Technology	W93-70072
506-49-00		506-43-00	
Space Communications Research and Technology	W93-70096	Systems Analysis	W93-70082
506-72-00		506-49-00	
In-Space Technology Experiments	W93-70103	University Space Engineering Research	W93-70086
506-74-00		506-50-00	
Surface Systems	W93-70116	Information and Controls Research and Technology	W93-70087
583-02-00		506-59-00	
Earth-to-Orbit Transportation	W93-70118	Human Support Research and Technology	W93-70094
584-03-00		506-71-00	
Space Transportation	W93-70122	Space Communications Research and Technology	W93-70097
584-04-00		506-72-00	
Earth-Orbiting Platforms	W93-70124	Interdisciplinary Technology	W93-70108
585-03-00		506-90-00	
Automation and Robotics	W93-70128		
586-02-00			
Electronic Materials	W93-70505		
674-21-05			
Combustion Science	W93-70507		
674-22-05			
Fluid Physics	W93-70511		
674-24-05			
Metals and Alloys	W93-70513		
674-25-05			
Glasses and Ceramics	W93-70515		
674-26-05			
Microgravity Materials Science Laboratory (MMSL)	W93-70517		
674-27-05			
Ground Experiment Operations	W93-70518		
674-28-05			
<b>NASA, Marshall Space Flight Center</b>			
Materials and Structures Research and Technology	W93-70076		
506-43-00			
In-Space Technology Experiments	W93-70106		
506-74-00			





# RTOP NUMBER INDEX

## RTOP SUMMARY

FISCAL YEAR 1993

### Typical RTOP Number Index Listing



Each report covered in this publication has been assigned an RTOP number by the responsible NASA organization. They are listed here in ascending number order. By cross-referencing the accession number, the user can locate the citation and technical summary in the summary section.

151-01-60	W93-70138	188-46-58	W93-70207	429-81-16	W93-70278
151-01-70	W93-70139	188-46-59	W93-70208	429-81-26	W93-70279
151-02-00	W93-70140		W93-70209	429-81-36	W93-70280
152-11-40	W93-70141	188-78-01	W93-70210	429-81-38	W93-70281
152-12-40	W93-70142		W93-70211	429-81-64	W93-70282
	W93-70143	188-78-41	W93-70212	429-81-72	W93-70283
152-13-40	W93-70144	188-78-44	W93-70213	429-81-80	W93-70284
152-13-60	W93-70145		W93-70214	429-81-84	W93-70285
152-14-40	W93-70146	188-78-60	W93-70215	429-81-95	W93-70286
152-17-40	W93-70147	196-41-03	W93-70216	429-81-96	W93-70287
152-20-01	W93-70148	196-41-50	W93-70217	429-81-97	W93-70288
152-20-40	W93-70149	196-41-52	W93-70218	429-81-99	W93-70289
152-30-40	W93-70150	196-41-54	W93-70219	429-97-04	W93-70290
152-88-10	W93-70151	196-41-67	W93-70220	431-06-00	W93-70291
154-10-80	W93-70152	196-88-01	W93-70221	432-20-00	W93-70292
154-20-80	W93-70153	196-88-01	W93-70222	432-36-00	W93-70293
	W93-70154	199-02-31	W93-70223	432-48-00	W93-70294
154-30-80	W93-70155		W93-70224	433-04-00	W93-70295
154-50-80	W93-70156	199-04-00	W93-70225	433-06-00	W93-70296
154-60-80	W93-70157	199-04-11	W93-70226	433-90-00	W93-70297
	W93-70158		W93-70227	435-11-00	W93-70298
154-75-80	W93-70159	199-04-14	W93-70228	440-62-59	W93-70299
154-90-80	W93-70160	199-06-11	W93-70229	440-63-44	W93-70300
154-95-80	W93-70161		W93-70230	452-11-93	W93-70301
155-04-00	W93-70162	199-06-12	W93-70231	452-21-93	W93-70302
	W93-70163	199-08-11	W93-70232	452-22-91	W93-70303
155-20-00	W93-70164	199-14-12	W93-70233	452-22-93	W93-70304
	W93-70165	199-16-12	W93-70234	452-23-94	W93-70305
155-20-02	W93-70166	199-18-12	W93-70235	452-33-93	W93-70306
155-20-03	W93-70167	199-26-11	W93-70236	452-89-81	W93-70307
155-20-04	W93-70168	199-26-12	W93-70237	460-20-00	W93-70308
157-03-50	W93-70169	199-26-14	W93-70238	460-21-00	W93-70309
157-03-70	W93-70170	199-40-21	W93-70239	460-21-28	W93-70310
	W93-70171	199-40-22	W93-70240	460-21-52	W93-70311
157-03-80	W93-70172	199-40-32	W93-70241	460-22-53	W93-70312
157-03-90	W93-70173	199-40-42	W93-70242	460-22-53	W93-70313
157-04-80	W93-70174	199-40-62	W93-70243	460-28-41	W93-70314
157-05-50	W93-70175	199-40-72	W93-70244	460-42-00	W93-70315
170-10-10	W93-70176	199-52-11	W93-70245	460-47-00	W93-70316
	W93-70177	199-52-12	W93-70246	460-97-00	W93-70317
	W93-70178	199-52-22	W93-70247	461-10-00	W93-70318
170-38-52	W93-70179	199-52-32	W93-70248	461-13-00	W93-70319
170-38-53	W93-70180	199-52-52	W93-70249	461-13-01	W93-70320
	W93-70181	199-52-54	W93-70250	461-13-02	W93-70321
186-06-01	W93-70182	199-52-82	W93-70251	461-31-09	W93-70322
188-41-21	W93-70183	199-55-19	W93-70252	461-31-13	W93-70323
	W93-70184	199-61-11	W93-70253	461-33-02	W93-70324
188-41-22	W93-70185	199-61-12	W93-70254	461-34-01	W93-70325
188-41-23	W93-70186	310-10-23	W93-70257	461-38-01	W93-70326
188-41-24	W93-70187	310-10-26	W93-70258	461-38-02	W93-70327
	W93-70188	310-10-60	W93-70259	461-38-05	W93-70328
188-41-51	W93-70189	310-10-61	W93-70260	461-38-05	W93-70329
188-41-57	W93-70190	310-10-62	W93-70261	461-50-00	W93-70330
	W93-70191	310-10-63	W93-70262	461-50-03	W93-70331
188-44-01	W93-70192	310-10-65	W93-70263	461-51-16	W93-70332
188-44-21	W93-70193	310-10-66	W93-70264	461-62-10	W93-70333
188-44-23	W93-70194	310-10-67	W93-70265	461-64-11	W93-70334
	W93-70195	310-10-69	W93-70266	461-66-16	W93-70335
	W93-70196	310-10-70	W93-70267	461-66-18	W93-70336
188-44-24	W93-70197	310-20-36	W93-70268	462-21-00	W93-70337
188-44-53	W93-70198	310-20-37	W93-70269	462-26-01	W93-70338
	W93-70199	310-20-38	W93-70270	462-31-63	W93-70339
	W93-70200	310-20-46	W93-70271	462-32-00	W93-70340
188-44-57	W93-70201	310-20-65	W93-70272	462-32-03	W93-70341
	W93-70202	310-20-66	W93-70273	462-32-61	W93-70342
	W93-70203	310-30-71	W93-70274	462-41-61	W93-70343
188-46-01	W93-70204	310-40-37	W93-70275	462-43-00	W93-70344
	W93-70205	310-40-45	W93-70276	462-61-00	W93-70345
188-46-57	W93-70206	310-40-47	W93-70277	462-61-03	W93-70346
		310-40-48		462-62-04	W93-70347
		310-40-49		462-62-05	W93-70348
		310-40-51		462-74-01	W93-70349
		310-40-73		462-75-62	W93-70350
		370-03-00		462-75-74	W93-70351
		399-18-00		462-76-49	W93-70352
		399-20-00		462-79-00	W93-70353
				463-11-01	W93-70354
				463-11-09	W93-70355
				463-11-62	W93-70356
				463-11-79	W93-70357
				463-43-00	W93-70358
				463-43-07	W93-70359
				463-61-00	W93-70360
				463-67-00	W93-70361
					W93-70362
					W93-70363
					W93-70364
					W93-70365
					W93-70366
					W93-70367
					W93-70368
					W93-70369
					W93-70370
					W93-70371
					W93-70372
					W93-70373

NUMBER

464-14-20	W93-70374		W93-70099	W93-70120
464-16-01	W93-70375	506-73-00	W93-70100	W93-70121
464-21-02	W93-70376		W93-70101	W93-70122
464-21-05	W93-70377	506-74-00	W93-70102	W93-70123
464-21-06	W93-70378		W93-70103	W93-70124
464-22-01	W93-70379		W93-70104	W93-70125
464-23-00	W93-70380		W93-70105	W93-70126
464-23-08	W93-70381		W93-70106	W93-70127
464-23-09	W93-70382	506-90-00	W93-70107	W93-70128
464-23-10	W93-70383	509-10-00	W93-70108	W93-70129
464-34-00	W93-70384		W93-70028	W93-70130
464-41-04	W93-70385		W93-70029	W93-70131
464-53-01	W93-70386		W93-70030	W93-70132
464-54-00	W93-70387		W93-70031	W93-70133
465-12-03	W93-70388	509-20-00	W93-70032	W93-70134
465-12-06	W93-70389		W93-70033	W93-70135
465-13-02	W93-70390		W93-70034	W93-70136
465-13-05	W93-70391		W93-70035	W93-70137
465-13-06	W93-70392	510-01-00	W93-70036	W93-70177
465-13-08	W93-70393	510-02-00	W93-70037	W93-70478
465-14-01	W93-70394		W93-70038	W93-70479
465-14-07	W93-70395	532-06-00	W93-70039	W93-70480
465-14-09	W93-70396		W93-70040	W93-70481
465-14-11	W93-70397	533-02-00	W93-70041	W93-70482
465-15-06	W93-70398		W93-70042	W93-70483
465-16-01	W93-70399		W93-70043	W93-70484
465-17-02	W93-70400	535-03-00	W93-70044	W93-70485
465-17-04	W93-70401		W93-70045	W93-70486
465-27-02	W93-70402	535-05-00	W93-70046	W93-70487
465-28-02	W93-70403	536-01-00	W93-70047	W93-70488
465-31-01	W93-70404	536-02-00	W93-70048	W93-70489
465-32-06	W93-70405	537-01-00	W93-70049	W93-70490
465-35-05	W93-70406		W93-70050	W93-70491
465-41-01	W93-70407		W93-70051	W93-70492
465-42-06	W93-70408		W93-70052	W93-70493
465-43-03	W93-70409	537-02-00	W93-70053	W93-70494
465-44-00	W93-70410		W93-70054	W93-70495
465-44-01	W93-70411		W93-70055	W93-70496
465-44-02	W93-70412	537-03-00	W93-70056	W93-70497
465-44-04	W93-70413		W93-70057	W93-70498
465-44-05	W93-70414	537-04-00	W93-70058	W93-70499
465-44-06	W93-70415	538-01-00	W93-70059	W93-70500
465-45-01	W93-70416		W93-70060	W93-70501
465-65-01	W93-70417	538-02-00	W93-70061	W93-70502
465-66-00	W93-70418	578-10-00	W93-70421	W93-70503
465-67-04	W93-70419	578-11-01	W93-70422	W93-70504
465-68-01	W93-70420	578-11-02	W93-70423	W93-70505
505-59-00	W93-70001	578-12-01	W93-70424	W93-70506
	W93-70002	578-12-02	W93-70425	W93-70507
	W93-70003	578-12-19	W93-70426	W93-70508
505-62-00	W93-70004	578-12-20	W93-70427	W93-70509
	W93-70005	578-12-21	W93-70428	W93-70510
505-63-00	W93-70006	578-12-59	W93-70429	W93-70511
	W93-70007	578-21-12	W93-70430	W93-70512
	W93-70008	578-22-24	W93-70431	W93-70513
	W93-70009	578-22-25	W93-70432	W93-70514
505-64-00	W93-70010	578-22-26	W93-70433	W93-70515
	W93-70011	578-22-27	W93-70434	W93-70516
	W93-70012	578-22-29	W93-70435	W93-70517
505-68-00	W93-70013	578-31-14	W93-70436	W93-70518
	W93-70014	578-32-24	W93-70437	W93-70519
	W93-70015	578-35-01	W93-70438	W93-70520
505-69-00	W93-70016	578-35-02	W93-70439	W93-70521
	W93-70017	578-35-04	W93-70440	W93-70522
	W93-70018	578-40-00	W93-70441	W93-70523
	W93-70019	578-41-01	W93-70442	W93-70524
505-70-00	W93-70020	578-41-43	W93-70443	W93-70525
	W93-70021	578-42-15	W93-70444	W93-70526
	W93-70022	578-90-00	W93-70445	
	W93-70023	578-97-12	W93-70446	
505-90-00	W93-70024	578-97-16	W93-70447	
	W93-70025	578-97-20	W93-70448	
	W93-70026	578-97-53	W93-70449	
	W93-70027	579-22-00	W93-70450	
506-40-00	W93-70062	579-23-01	W93-70451	
	W93-70063	579-23-10	W93-70452	
506-41-00	W93-70064	579-24-00	W93-70453	
	W93-70065	579-24-06	W93-70454	
	W93-70066	579-24-09	W93-70455	
	W93-70067	579-31-01	W93-70456	
506-42-00	W93-70068	579-31-02	W93-70457	
	W93-70069	579-31-07	W93-70458	
	W93-70070	579-32-06	W93-70459	
506-43-00	W93-70071	579-36-03	W93-70460	
	W93-70072	579-36-09	W93-70461	
	W93-70073	579-36-10	W93-70462	
	W93-70074	579-36-11	W93-70463	
	W93-70075	579-41-00	W93-70464	
	W93-70076	579-41-04	W93-70465	
	W93-70077	579-41-08	W93-70466	
506-48-00	W93-70078	579-42-01	W93-70467	
	W93-70079	579-42-02	W93-70468	
	W93-70080	579-42-03	W93-70469	
	W93-70081	579-42-11	W93-70470	
506-49-00	W93-70082	579-42-13	W93-70471	
	W93-70083	579-43-00	W93-70472	
	W93-70084	579-82-00	W93-70473	
	W93-70085	579-82-90	W93-70474	
506-50-00	W93-70086	579-97-00	W93-70475	
506-59-00	W93-70087	579-98-00	W93-70476	
	W93-70088	582-03-00	W93-70109	
	W93-70089		W93-70110	
	W93-70090		W93-70111	
	W93-70091		W93-70112	
506-71-00	W93-70092	582-04-00	W93-70113	
	W93-70093		W93-70114	
	W93-70094		W93-70115	
	W93-70095	583-02-00	W93-70116	
506-72-00	W93-70096		W93-70117	
	W93-70097	584-03-00	W93-70118	
	W93-70098		W93-70119	

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